

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
28 August 2003 (28.08.2003)

PCT

(10) International Publication Number  
**WO 03/070731 A2**

(51) International Patent Classification<sup>7</sup>: C07D 519/00,  
A61K 31/404, A61P 25/00

(21) International Application Number: PCT/US03/02682

(22) International Filing Date: 13 February 2003 (13.02.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/357,926 19 February 2002 (19.02.2002) US

(71) Applicant (for all designated States except US): PHARMACIA & UPJOHN COMPANY [US/US]; 301 Henrietta Street, Kalamazoo, MI 49001 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): WALKER, Daniel, P. [US/US]; 9350 Highlandview Drive, Kalamazoo, MI 49009 (US). PIOTROWSKI, David, W. [US/US]; 3248 Lost Pine Way, Portage, MI 49024 (US). JACOBSEN, Eric, Jon [US/US]; 6233 Bethany Circle, Richland, MI

49083 (US). ACKER, Brad, A. [US/US]; 1734 Tanager Lane, Kalamazoo, MI 49009 (US). GROPP, Jr., Vincent, E. [US/US]; 318 Sprague Avenue, Kalamazoo, MI 49006 (US).

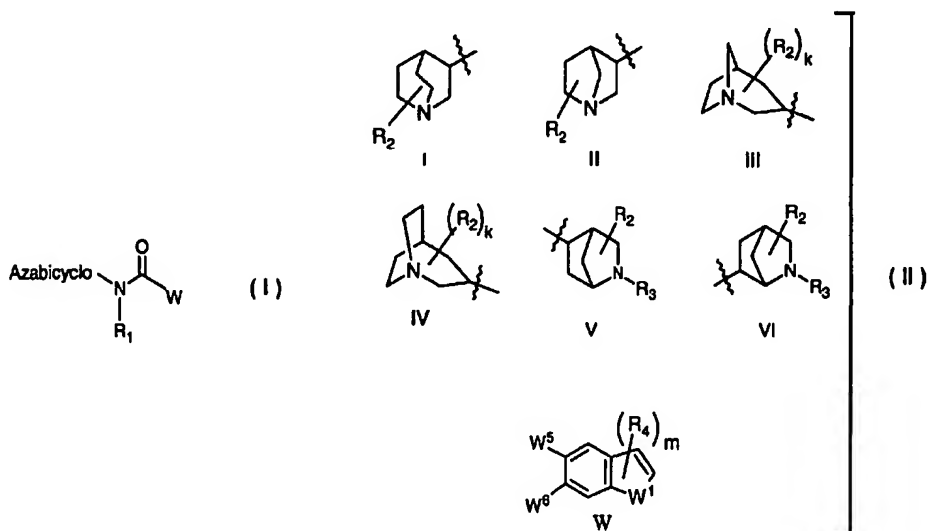
(74) Agent: HOSLEY, Mary, J.; Global Intellectual Property, Pharmacia & Upjohn Company; 301 Henrietta Street, Kalamazoo, MI 49001 (US).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: AZABICYCLIC COMPOUNDS FOR THE TREATMENT OF DISEASE



(57) Abstract: The invention provides compounds of Formula I: These compounds may be in the form of pharmaceutical salts or compositions, may be in pure enantiomeric form or racemic mixtures, and are useful in pharmaceuticals in which  $\alpha 7$  is known to be involved.

WO 03/070731 A2

WO 03/070731 A2



**Published:**

— without international search report and to be republished  
upon receipt of that report

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## AZABICYCLIC COMPOUNDS FOR THE TREATMENT OF DISEASE

### FIELD OF INVENTION

Nicotinic acetylcholine receptors (nAChRs) play a large role in central nervous system (CNS) activity. Particularly, they are known to be involved in cognition, learning, mood, emotion, and neuroprotection. There are several types of nicotinic acetylcholine receptors, and each one appears to have a different role in regulating CNS function. Nicotine affects all such receptors, and has a variety of activities. Unfortunately, not all of the activities are desirable. In fact, one of the least desirable properties of nicotine is its addictive nature and the low ratio between efficacy and safety. The present invention relates to molecules that have a greater effect upon the  $\alpha 7$  nAChRs as compared to other closely related members of this large ligand-gated receptor family. Thus, the invention provides compounds that are active drug molecules with fewer side effects.

The invention also concerns the synthesis of and isolation of intermediates and final compounds. Specifically, the present invention concerns the selective synthesis of (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine or salts thereof.

### BACKGROUND OF THE INVENTION

Cell surface receptors are, in general, excellent and validated drug targets. nAChRs comprise a large family of ligand-gated ion channels that control neuronal activity and brain function. These receptors have a pentameric structure. In mammals, this gene family is composed of nine alpha and four beta subunits that co-assemble to form multiple subtypes of receptors that have a distinctive pharmacology. Acetylcholine is the endogenous regulator of all of the subtypes, while nicotine non-selectively activates all nAChRs.

The  $\alpha 7$  nAChR is one receptor system that has proved to be a difficult target for testing. Native  $\alpha 7$  nAChR is not routinely able to be stably expressed in most mammalian cell lines (Cooper and Millar, *J. Neurochem.*, 1997, 68(5):2140-51). Another feature that makes functional assays of  $\alpha 7$  nAChR challenging is that the receptor is rapidly (100 milliseconds) inactivated. This rapid inactivation greatly limits the functional assays that can be used to measure channel activity.

Recently, Eisele et al. has indicated that a chimeric receptor formed between the N-terminal ligand binding domain of the  $\alpha 7$  nAChR (Eisele et al., *Nature*, 366(6454), p 479-83, 1993), and the pore forming C-terminal domain of the 5-HT<sub>3</sub> receptor expressed well in *Xenopus* oocytes while retaining nicotinic agonist sensitivity. Eisele et al. used the N-terminus of the avian (chick) form of the  $\alpha 7$  nAChR receptor and the C-terminus of the mouse form of the 5-HT<sub>3</sub> gene. However, under physiological conditions the  $\alpha 7$  nAChR is a calcium channel while the 5-HT<sub>3</sub>R is a sodium and potassium channel. Indeed, Eisele et al. teaches that the chicken  $\alpha 7$  nAChR/ mouse 5-HT<sub>3</sub>R behaves quite differently than the native  $\alpha 7$  nAChR with the pore element not conducting calcium but actually being blocked by calcium ions. WO 00/73431 A2 reports on assay conditions under which the 5-HT<sub>3</sub>R can be made to conduct calcium. This assay may be used to screen for agonist activity at this receptor.

US Patent 5,977,144 discloses compositions for benzylidene- and cinnamylidene-anabaseines and methods for using these compositions for treating conditions associated with defects or malfunctioning of nicotinic subtypes brain receptors. These compositions target the  $\alpha 7$  receptor subtype with little or no activation of the  $\alpha 4\beta 2$  or other receptor subtypes.

US Patent 5,599,937 discloses heteroaromatic quinuclidines used for treating diseases related to muscarinic receptor function.

US Patent 5,561,149 discloses the use of a mono or bicyclic carbocyclic, or heterocyclic carboxylic acid, ester or amide or an imidazolyl carbazol in the manufacture of a medicament suitable for the treatment of stress-related psychiatric disorders, for increasing vigilance, for the treatment of rhinitis or serotonin-induced disorders and/or coadministration with another active agent to increase the bioavailability thereof, or for nasal administration.

US Patent 5,543,426 discloses the use of certain 3,7-disubstituted indole compounds for treating depression or cognitive disorders.

US Patent 5,434,161 discloses imidazopyridines as serotonergic 5-HT<sub>3</sub> antagonists.

US Patent 5,362,740 discloses dihydrobenzofuran carboxamides useful in treating CNS disorders, but motility disorders, and/or emesis and/or pain in mammals, and/or migraine.



US Patent 5,352,685 discloses thieno[3,2-b]pyridine derivatives effective for the prevention and therapeutical treatment of the symptoms caused by gastric hypanakinesis, such as heartburn, abdominal distension feeling, anorexia, unpleasant feeling on upper abdomen, abdominalgia, nausea, vomiting, etc. caused by the  
5 underlying diseases such as acute and chronic gastritis, stomach and duodenum ulcer, gastroneurosis, gastropptosis, etc.

US Patent 5,342,845 discloses indole derivatives and drugs. The compound of the invention is disclosed as being effective as a gastrointestinal motor activity regulator, antimigraine, antipsychotic or antianxiety drug and for dementia or  
10 orthostatic hypotension.

US Patent 5,322,951 discloses certain 1-(2,3-dihydro-indole)carbonyl intermediates useful for preparing 1-(2,3-dihydro)-1-carboxamide final products that possess 5-HT M-receptor antagonist activity.

US Patent 5,272,154 discloses 3,7 substituted indole and indazole compounds  
15 and pharmaceutical compositions containing them and are disclosed as being useful for the treatment of psychiatric disorders.

US Patent 5,217,975 discloses azabicyclic compounds for treating dementia.

US Patent 5,114,947 discloses a method for alleviating anxiety using benzobicyclic carboxamides.

20 US Patent 5,039,680 discloses 5-HT<sub>3</sub> antagonists in preventing or reducing dependency on dependency-inducing agents.

US Patent 5,001,133 discloses substituted benzoic acid heterocyclic amides and esters as being serotonin M antagonists.

US Patent 4,985,437 discloses the use of certain compounds which act as  
25 antagonists of 5-hydroxytryptamine (5-HT) at 5-HT<sub>3</sub> receptors for the treatment of cognitive disorders such as attentional and memory deficits and dementia states.

US Patent 4,983,600 discloses heterocyclic compounds useful as 5-HT<sub>3</sub> antagonists.

US Patent 4,973,594 discloses the use of compounds which act as antagonists  
30 of 5-hydroxytryptamine (5-HT) at 5-HT<sub>3</sub> receptors for the treatment of depression.

US Patent 4,937,247 discloses 1-acyl indazoles that are disclosed as having 5-HT<sub>3</sub> antagonist activity.

US Patent 4,935,511 discloses benzoxazine and benzoxazepin carboxamide 5-HT<sub>3</sub> antagonists properties including CNS, anti-emetic and gastric prokinetic activity and which are void of any significant D<sub>2</sub> receptor binding affinity.

US Patent 4,921,982 discloses 5-halo-2,3-dihydro-2,2-dimethylbenzofuran-7-carboxylic acids which are useful as intermediates for 5-HT<sub>3</sub> antagonists.

US Patent 4,920,219 discloses substituted saturated and unsaturated indole quinoline and benzazepine carboxamides and their valuable use as 5-HT<sub>3</sub> antagonists having CNS and gastric prokinetic activity void of any significant D<sub>2</sub> receptor binding properties.

US Patent 4,920,127 discloses substituted indoles and their use as 5-HT<sub>3</sub> receptor antagonists.

US Patent 4,910,193 discloses treatment of gastrointestinal disorders.

US Patent 4,888,353 discloses carboxamides useful as antiemetic or antipsychotic agents.

US Patent 4,882,327 discloses certain heterocyclic N-substituted carboxamides having 5-HT<sub>3</sub> receptor antagonist activity.

US Patent 4,845,092 discloses a method of treatment of visceral pain in mammals, including humans.

US Patent 4,835,162 discloses agonists and antagonists to nicotine as smoking deterrents.

US Patent 4,822,795 discloses pharmaceutically useful esters and amides.

US Patent 4,803,199 discloses pharmaceutically useful heterocyclic acid esters and amides or alkylene bridged piperidines as serotonin M antagonists.

US Patent 4,798,829 discloses 1-azabicyclo[3.2.2]nonane derivatives having gastric motility enhancing activity and/or anti-emetic activity and/or 5-HT receptor antagonist activity.

US Patent 4,797,406 discloses amides and esters containing bridged piperidines and use as serotonin M antagonists.

US Patent 4,721,720 discloses a method of treating emesis, anxiety and/or irritable bowel syndrome.

US Patent 4,612,319 discloses bridged quinolizinidinylamides, compositions containing them and methods for their use.

US Patent 4,605,652 discloses a method of enhancing memory or correcting memory deficiency with arylamido (and arylthioamido)-azabicycloalkanes, and the pharmaceutically acceptable acid addition salts, hydrates and alcoholates thereof.

WO 01/76576 A2 discloses a pharmaceutical composition for treatment of  
5 acute, chronic pain and/or neuropathic pain and migraines.

WO 01/60821 A1 discloses novel biarylcarboxamides and their use in therapy, especially in the treatment of prophylaxis of psychotic and intellectual impairment conditions.

WO 01/36417 A1 discloses novel N-azabicyclo-amide derivatives and use in  
10 therapy, especially in the treatment of prophylaxis of psychotic disorders and intellectual impairment disorders.

WO 00/73431 A2 discloses two binding assays to directly measure the affinity and selectivity of compounds at the  $\alpha 7$  nAChR and the 5-HT<sub>3</sub>R. The combined use of these functional and binding assays may be used to identify compounds that are  
15 selective agonists of the  $\alpha 7$  nAChR.

WO 99/20633 discloses benzoazine derivatives having an antagonist activity for 5-HT<sub>3</sub>/5-HT<sub>4</sub> receptors.

WO 97/35860 discloses novel benzimidazol derivatives having an affinity for the serotonergic 5-HT<sub>3</sub>/5-HT<sub>4</sub> receptors.

20 WO 96/33186 discloses substituted dihydrobenzofuran derivatives as 5-HT<sub>4</sub> agonists.

WO 95/27490 discloses serotonin antagonists (5-HT<sub>3</sub>) for treating fibromyalgia.

WO 95/04742 discloses tropyl 7-azaindol-3-ylcarboxyamides as antitussive  
25 agents.

WO 92/10494 discloses novel compounds that are 5-HT<sub>3</sub> receptor antagonists.

WO 91/17161 discloses isoquinoline amides and esters as 5-HT<sub>3</sub> receptor antagonists.

WO 91/09593 discloses 5-HT<sub>3</sub> antagonists for treatment of nausea,  
30 bradycardia or hypotension associated myocardial instability.

WO 90/14347 A as abstracted in chemical abstract 1991:143,158 discloses N-quinuclidinyl-indolecarboxamide derivatives as being antiemetics.

EP 512 350 A2 discloses 3-(indolyl-2-carboxamido) quinuclidines useful for treating diseases characterized by an excess or enhanced sensitivity to serotonin, e.g., psychosis, nausea, vomiting, dementia or other cognitive diseases, migraine, diabetes. The compound may be used to control anxiety, aggression, depression, and pain. The compounds are disclosed as serotonin 5-HT<sub>3</sub> antagonists.

EP 496 064 A1 discloses a process for the preparation of substituted benzofuran derivatives. The compounds are disclosed as being useful 5-HT<sub>3</sub> receptor antagonists.

EP 483 836 A1 discloses pyrazolo[1,5-a]pyridine-3-carboxylic acid derivatives, their preparation process, and serotonin receptor antagonists containing them as active ingredients.

DE 3810552 A1 discloses esters and amides of indolyl-, benzo[b]thiophenyl-, benzo[b]furancarboxylic acids or 4-amino-2 methoxy-benzoic acids with N-heterocyclic or N-heterobicyclic alcohols or amines. The compounds disclosed have activity against pain especially migraine, as an anti-arrhythmic for gastrointestinal disturbances, stomach disturbances, gastritis ulcer, gall bladder, spastic colon, Crohn's disease, ulcerative colitis, carcinoid syndrome, diarrhea of various types. The compounds are also disclosed as speeding stomach emptying, controlling gastro duodenal and gastro esophageal reflux, disturbances of esophageal motility, hiatal hernia, cardiac insufficiency, hypotonic stomach, paralytic ileus, manic depressive psychosis and other psychoses. The compounds are also disclosed as useful for stress related diseases, senility, and enhancement of nasal absorption of other agents, e.g., in the treatment of emesis.

In *Bioorg. & Med.Chem. Lett.* 11 (2001) 319-321, the 5-HT<sub>3</sub> antagonist tropisetron (ICS 205-930) is discussed as a potent and selective  $\alpha 7$  nicotinic receptor partial agonist.

In *Behavioral Brain Res.*, 113 (2000) 169-181, it is discussed that the brain  $\alpha 7$  nicotinic receptor may be an important therapeutic target for the treatment of Alzheimer's disease using DMXBA which is known as GTS-21.

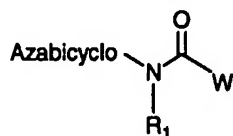
In *Bioorg. & Med.Chem. Lett.* 9 (1999) 1895-1900, it is discussed the discovery of a highly potent, functionally-selective muscarinic M<sub>1</sub> agonist.

In *Bioorg. & Med.Chem. Lett.* 4 (1994) 695-698, it is discussed pyrazolo[1,5-a]pyridines and pyrazolo[1,5-b]pyridazines as 5-HT<sub>3</sub> antagonists.

In *Eur. J. Med. Chem.*, 34 (1999) 415-422, benzimidazole-2-carboxylic acid amides and esters are discussed as a new structural class of 5-HT<sub>3</sub> ligands.

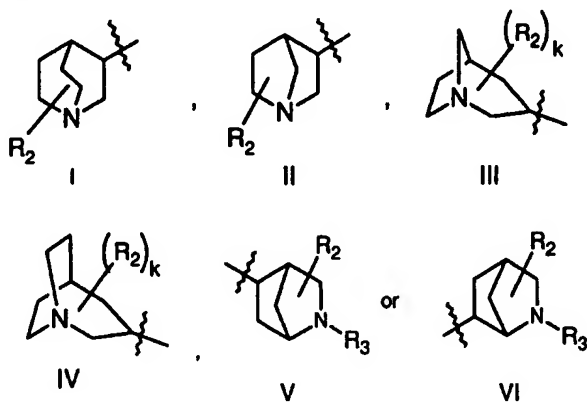
# SUMMARY OF THE INVENTION

5 The present invention discloses compounds of the Formula I:

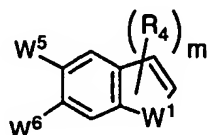


Formula I

wherein Azabicyclo is



10 W is



R<sub>1</sub> is H, alkyl, halogenated alkyl, cycloalkyl, substituted phenyl, or substituted naphthyl;

R<sub>2</sub> is H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or  
15 aryl;

k is 1 or 2, provided that when k is 2, each R<sub>2</sub> is other than H;

R<sub>3</sub> is H, lower alkyl, lower substituted alkyl, or lower halogenated alkyl;

W<sup>1</sup> is O, S, or N(R<sub>15</sub>);

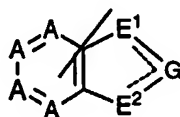
W<sup>5</sup> and W<sup>6</sup> are independently H or a bond to the carbonyl of Formula I,  
20 provided that only one of W<sup>5</sup> and W<sup>6</sup> is said bond and the other is H;

Each  $R_4$  is independently H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, halogenated alkynyl, substituted alkynyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, lactam  
 5 heterocycloalkyl, phenyl, substituted phenyl,  $-OR_{10}$ ,  $-SR_{10}$ ,  $-SOR_{10}$ ,  $-SO_2R_{10}$ ,  $-NR_{10}C(O)R_5$ ,  $-NR_{10}C(O)R_6$ ,  $-NR_{10}C(O)R_8$ ,  $-NR_{10}C(O)R_{10}$ ,  $-N(R_{10})_2$ ,  $-NO_2$ ,  $-C(O)R_{10}$ ,  $-CN$ ,  $-C(O)_2R_{10}$ ,  $-C(O)NHR_{10}$ ,  $-SCN$ ,  $-S(O)NHR_{10}$ ,  $-S(O)_2NHR_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ ,  $R_5$ , or  $R_6$ , provided that when  $R_4$  is  $-SO_{1-2}R_{10}$  or  $-CO_{1-2}R_{10}$  and  $R_{10}$  is heterocycle, halogenated heterocycle or heterocycle substituted with 1 substituent  
 10 selected from  $R_{13}$ , a carbon in the heterocycle is bonded to the carbon or sulfur;

$m$  is 1 or 2, provided that when  $m$  is 2 each  $R_4$  is other than H;

$R_5$  is a 5-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms independently selected from the group consisting of  $-O-$ ,  $=N-$ ,  $-N(R_{16})-$ , and  $-S-$ , and having 0-1 substituent selected from  $R_9$ , and further having 0-3  
 15 substituents independently selected from F, Cl, Br, or I,

or  $R_5$  is a 9-membered fused-ring moiety having a 6-membered ring fused to a 5-membered ring and having the formula



wherein each A is independently  $CR_{14}$  or N, provided that only up to one A is N,  $E^1$   
 20 and  $E^2$  are independently selected from  $CR_{14}$ , O, S, or  $NR_{16}$ , and G is  $CR_{14}$ , provided that  $R_{14}$  or  $R_{16}$  can be a bond when --- forms a double bond and further provided that only one  $R_{14}$  or  $R_{16}$  can be a bond for bonding  $R_5$  to a moiety to which it is attached;

$R_6$  is a 6-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms selected from  $=N-$  and having 0-1 substituent selected from  $R_9$   
 25 and 0-3 substituent(s) independently selected from F, Cl, Br, or I,

or  $R_6$  is a 10-membered heteroaromatic bi-cyclic moiety containing within one or both rings 1-3 heteroatoms selected from  $=N-$ , including, but not limited to, quinolinyl or isoquinolinyl, each 10-membered fused-ring moiety having 0-1 substituent selected from  $R_9$ , and 0-3 substituent(s) independently selected from F, Cl,  
 30 Br, or I;

$R_7$  is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, phenyl, or phenyl having 0-4 substituents independently selected from F, Cl, Br, I, and  $R_9$ ;

Each  $R_8$  is independently H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, phenyl, or phenyl substituted with 0-4 independently selected from F, Cl, Br, I, or  $R_9$ ;

$R_9$  is alkyl, substituted alkyl, halogenated alkyl, -OR<sub>11</sub>, -CN, -NO<sub>2</sub>, -NR<sub>10</sub>R<sub>10</sub>;

Each  $R_{10}$  is independently H, alkyl, cycloalkyl, heterocycloalkyl, alkyl substituted with 1 substituent selected from  $R_{13}$ , cycloalkyl substituted with 1 substituent selected from  $R_{13}$ , heterocycloalkyl substituted with 1 substituent selected from  $R_{13}$ , halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, phenyl, or substituted phenyl;

Each  $R_{11}$  is independently H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, or halogenated heterocycloalkyl;

$R_{12}$  is -OR<sub>11</sub>, -SR<sub>11</sub>, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, or -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>;

$R_{13}$  is -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -SOR<sub>11</sub>, -SO<sub>2</sub>R<sub>11</sub>, -C(O)NR<sub>11</sub>R<sub>11</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>;

Each  $R_{14}$  is independently bond, H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, F, Cl, Br, I, or a bond, provided that the fused-ring moiety has 0-1 substituent selected from alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, or -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, and further provided that the fused-ring moiety has 0-3 substituent(s) selected from F, Cl, Br, or I;

$R_{15}$  is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

Each  $R_{16}$  is independently bond, H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

or pharmaceutical composition, pharmaceutically acceptable salt, racemic mixture, or pure enantiomer thereof.

Embodiments of the invention may include one or more or combination of the following.

The present invention also includes a method to treat using a compound according to Formula I or pharmaceutically acceptable salt thereof, or use of a compound according to Formula I or pharmaceutically acceptable salt thereof to prepare a medicament for treating, a disease or condition, wherein the mammal would receive symptomatic relief from the administration of a therapeutically effective amount of  $\alpha 7$  nicotinic acetylcholine receptor agonist.

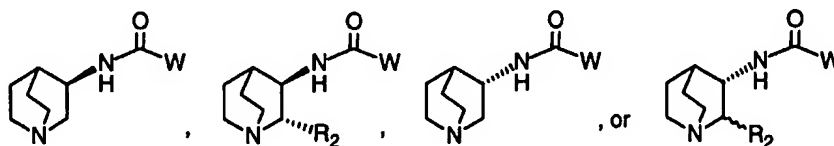
The compounds of Formula I are used to treat, or make a medicament to treat, a disease or condition, wherein the disease or condition is any one or more or combination of the following: cognitive and attention deficit symptoms of Alzheimer's, neurodegeneration associated with diseases such as Alzheimer's disease, pre-senile dementia (mild cognitive impairment), senile dementia, schizophrenia, psychosis, attention deficit disorder, attention deficit hyperactivity disorder, depression, anxiety, general anxiety disorder, post traumatic stress disorder, mood and affective disorders, amyotrophic lateral sclerosis, borderline personality disorder, traumatic brain injury, behavioral and cognitive problems in general and associated with brain tumors, AIDS dementia complex, dementia associated with Down's syndrome, dementia associated with Lewy Bodies, Huntington's disease, Parkinson's disease, tardive dyskinesia, Pick's disease, dysregulation of food intake including bulimia and anorexia nervosa, withdrawal symptoms associated with smoking cessation and dependant drug cessation, Gilles de la Tourette's Syndrome, age-related macular degeneration, glaucoma, neurodegeneration associated with glaucoma, or symptoms associated with pain.



The compounds of Formula I are used to make pharmaceutical composition(s) comprising a compound of Formula I, a pharmaceutically acceptable excipient, and optionally anti-psychotic agent(s), e.g., at least one anti-psychotic agent. The pharmaceutical composition(s) is administered so the compound of Formula I and the agent if it is present are to be independently administered rectally, topically, orally, sublingually, or parenterally for a therapeutically effective interval. The compound of Formula I is administered in an amount of from about 0.001 to about 100 mg/kg of body weight of said mammal per day, including from about 0.1 to about 50 mg/kg of body weight of said mammal per day. One of ordinary skill in the art will know how to administer the anti-psychotic agent(s).

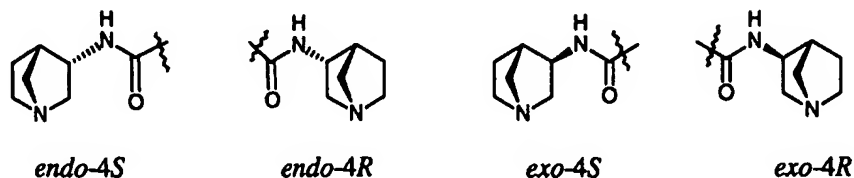
In another aspect, the invention includes methods of treating a mammal suffering from schizophrenia or psychosis by administering compounds of Formula I in conjunction with antipsychotic drug(s), e.g., at least one anti-psychotic agent. The compounds of Formula I and the antipsychotic drugs can be administered simultaneously or at separate intervals. When administered simultaneously the compounds of Formula I and the antipsychotic drugs can be incorporated into a single pharmaceutical composition. Alternatively, two separate compositions, i.e., one containing compounds of Formula I and the other containing antipsychotic drugs, can be administered simultaneously.

The compounds of Formula I (Azabicyclo is I) have asymmetric center(s) on the quinuclidine ring. The compounds of the present invention include quinuclidines with the 3*R* configuration, 3*R*,2*S* configuration, 3*S* configuration, or 3*S* configuration without a specific configuration at C-2, and also includes racemic mixtures, the separate stereoisomers, and compositions of varying degrees of stereochemical purity. For example, and not by limitation, compounds of Formula I include compounds with stereospecificity including:



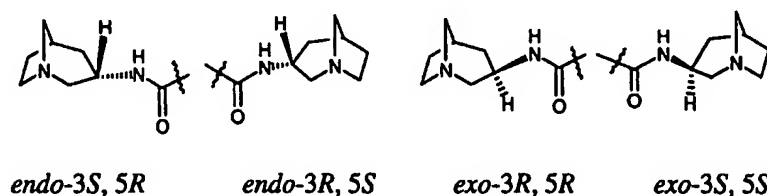
The compounds of Formula I (Azabicyclo is II) have asymmetric center(s) on the [2.2.1] azabicyclic ring at C3 and C4. The scope of this invention includes racemic mixtures of varying degrees of stereochemical purities, the separate

stereoisomers, and compositions of varying degrees of stereochemical purities of Formula I being *endo-4S*, *endo-4R*, *exo-4S*, *exo-4R*:

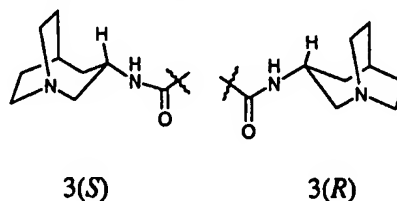


- 5 The *endo* isomer is the isomer where the non-hydrogen substituent at C3 of the [2.2.1] azabicyclic compound is projected toward the larger of the two remaining bridges. The *exo* isomer is the isomer where the non-hydrogen substituent at C3 of the [2.2.1] azabicyclic compound is projected toward the smaller of the two remaining bridges. Thus, there can be four separate isomers: *exo-4(R)*, *exo-4(S)*, *endo-4(R)*, and *endo-*  
10 *4(S)*.

- The compounds of Formula I (Azabicyclo is III) have asymmetric center(s) on the [3.2.1] azabicyclic ring at C3 and C5. The scope of this invention includes racemic mixtures of varying degrees of stereochemical purities, the separate stereoisomers, and compositions of varying degrees of stereochemical purities of  
15 Formula I being *endo-3S*, *5R*, *endo-3R*, *5S*, *exo-3R*, *5R*, *exo-3S*, *5S*:

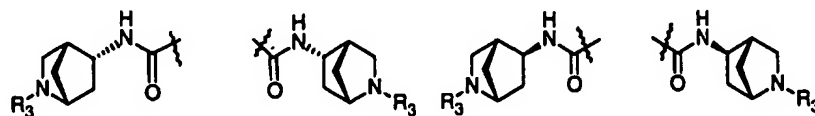


- The compounds of Formula I (Azabicyclo is IV) have asymmetric centers on the [3.2.2] azabicyclic ring with one center being at C3 when R<sub>2</sub> is absent. The scope  
20 of this invention includes racemic mixtures of varying degrees of stereochemical purities, the separate stereoisomers, and compositions of varying degrees of stereochemical purities of Formula I being 3(*S*) and 3(*R*):



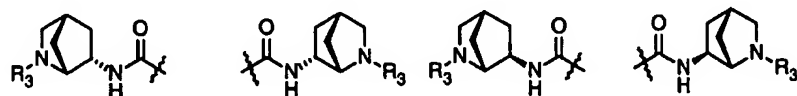
- 25 The compounds of Formula I (Azabicyclo V) have asymmetric center(s) on the [2.2.1] azabicyclic ring at C1, C4 and C5. The scope of this invention includes racemic mixtures of varying degrees of stereochemical purities, the separate

stereoisomers, and compositions of varying degrees of stereochemical purities of Formula I being (1*R*,4*R*,5*S*), (1*R*,4*R*,5*R*), (1*S*,4*S*,5*R*), (1*S*,4*S*,5*S*):

*endo*-1*R*,4*R*,5*R**endo*-1*S*,4*S*,5*S**exo*-1*R*,4*R*,5*S**exo*-1*S*,4*S*,5*R*

- 5 The *endo* isomer is the isomer where the non-hydrogen substituent at C5 of the [2.2.1] azabicyclic compound is projected toward the larger of the two remaining bridges. The *exo* isomer is the isomer where the non-hydrogen substituent at C5 of the [2.2.1] azabicyclic compound is projected toward the smaller of the two remaining bridges. Thus, there can be four separate isomers: *exo*-(1*R*,4*R*,5*S*), *exo*-(1*S*,4*S*,5*R*), *endo*-(1*S*,4*S*,5*S*), *endo*-(1*R*,4*R*,5*R*).

- 10 The compounds of Formula I (Azabicyclo VI) have asymmetric center(s) on the [2.2.1] azabicyclic ring at C1, C4 and C6. The scope of this invention includes racemic mixtures of varying degrees of stereochemical purities, the separate stereoisomers, and compositions of varying degrees of stereochemical purities of Formula I being *exo*-(1*S*,4*R*,6*S*), *exo*-(1*R*,4*S*,6*R*), *endo*-(1*S*,4*R*,6*R*), and *endo*-(1*R*,4*S*,6*S*):

*endo*-1*R*,4*S*,6*S**endo*-1*S*,4*R*,6*R**exo*-1*R*,4*S*,6*R**exo*-1*S*,4*R*,6*S*

- 20 The *endo* isomer is the isomer where the non-hydrogen substituent at C6 of the [2.2.1] azabicyclic compound is projected toward the larger of the two remaining bridges. The *exo* isomer is the isomer where the non-hydrogen substituent at C6 of the [2.2.1] azabicyclic compound is projected toward the smaller of the two remaining bridges. Thus, there can be four separate isomers: *exo*-(1*S*,4*R*,6*S*), *exo*-(1*R*,4*S*,6*R*), *endo*-(1*S*,4*R*,6*R*), and *endo*-(1*R*,4*S*,6*S*).

- 25 The compounds of the present invention having the specified stereochemistry have different levels of activity and that for a given set of values for the variable substituents one isomer may be preferred over the other isomers. Although it is desirable that the stereochemical purity be as high as possible, absolute purity is not required. This invention involves racemic mixtures and compositions of varying degrees of stereochemical purities when the Azabicyclo is substituted with only the

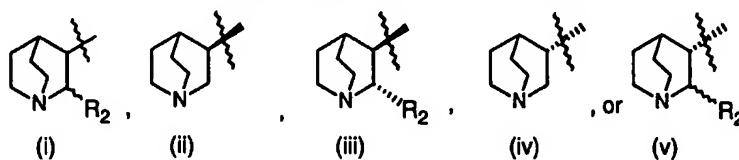
amide or is substituted with substituents in addition to the amide, e.g.,  $R_2$  is alkyl.

When racemic mixtures and compositions are referenced, it is meant racemic mixtures and compositions of varying degrees of stereochemical purities. It is preferred to carry out stereoselective syntheses and/or to subject the reaction product to appropriate purification steps so as to produce substantially enantiomerically pure materials. Suitable stereoselective synthetic procedures for producing enantiomerically pure materials are well known in the art, as are procedures for purifying racemic mixtures into enantiomerically pure fractions.

Stereoselective syntheses and/or subjecting the reaction product to appropriate purification steps produces substantially enantiomerically pure materials. Suitable stereoselective synthetic procedures for producing enantiomerically pure materials are well known in the art, as are procedures for purifying racemic mixtures into enantiomerically pure fractions.

The compound of Formula I, where Azabicyclo is any one or more of the following: I, II, III, IV, V, or VI.

Another embodiment of the compounds of Formula I includes any one or more or combination of the following configurations for Azabicyclo:



where (i) the compound is a mixture of diastereomers,

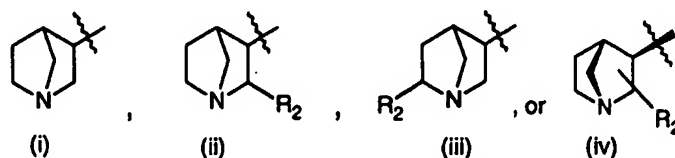
(ii) the compound has the *R* absolute stereochemistry at C-3,

(iii) the compound has the *R* absolute stereochemistry at C-3 and the *S* absolute stereochemistry at C-2 as discussed herein and  $R_2$  is other than H,

(iv) the compound has the *S* absolute stereochemistry at C-3, or

(v) the compound has the *S* absolute stereochemistry at C-3 and is a mixture of diastereomers at C-2 as discussed herein and  $R_2$  is other than H.

Another embodiment of compounds of Formula I includes any one or more or combination of the following configurations for Azabicyclo:



where (i)  $R_2$  is H;

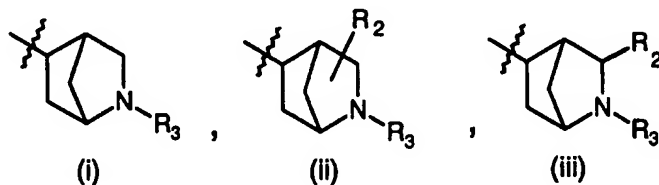
(ii)  $R_2$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

(iii)  $R_2$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl; or

(iv) the 2.2.1 moiety has the *exo*-4(*S*) absolute stereochemistry as discussed

5 herein and  $R_2$  can have any definition discussed herein.

Another embodiment of compounds of Formula I includes any one or more or combination of the following configurations for Azabicyclo:

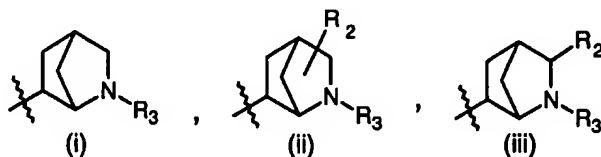


where (i)  $R_2$  is H;

10 (ii)  $R_2$  is F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl; or

(iii)  $R_2$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl.

Another embodiment of compounds of Formula I includes any one or more or combination of the following configurations for Azabicyclo:



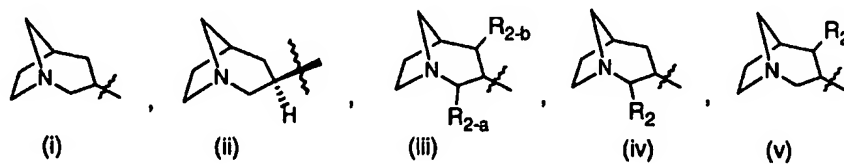
15

where (i)  $R_2$  is H;

(ii)  $R_2$  is F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl; or

(iii)  $R_2$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl.

20 Another embodiment of compounds of Formula I includes any one or more or combination of the following configurations for Azabicyclo:



where (i)  $R_2$  is H and k is 1;

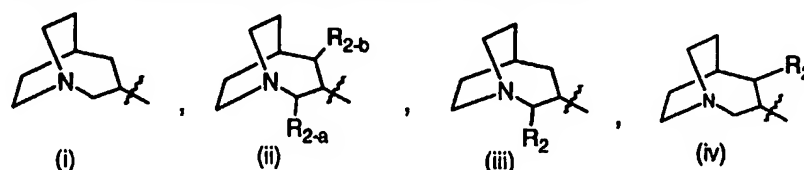
(ii)  $R_2$  is H and where the Azabicyclo has the absolute stereochemistry of 3*R*, 5*R*;

(iii)  $k$  is 2, where  $R_{2-a}$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl, and where  $R_{2-b}$  is F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

(iv)  $k$  is 1, where  $R_2$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl; or

(v)  $k$  is 1, where  $R_2$  is F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl.

Another embodiment of compounds of Formula I includes any one or more or combination of the following configurations for Azabicyclo:



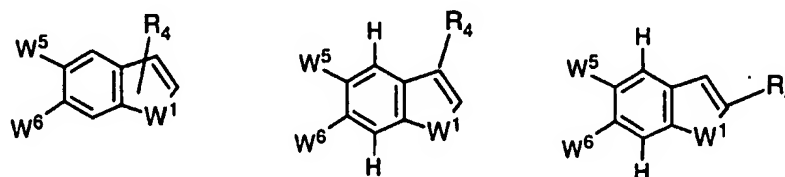
where (i)  $R_2$  is H and  $k$  is 1;

(ii)  $k$  is 2, where each  $R_{2-a}$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl and where each  $R_{2-b}$  is F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

(iii)  $k$  is 1, where  $R_2$  is alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl; or

(iv)  $k$  is 1, where  $R_2$  is F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl.

Another embodiment of compounds of Formula I includes any one or more or combination of the following configurations for W:



Another group of compounds of Formula I includes compounds where  $W^1$  is O. Another group of compounds of Formula I includes compounds where  $W^1$  is S. Another group of compounds of Formula I includes compounds where  $W^5$  and  $W^6$  are independently H or a bond. Another group of compounds of Formula I includes

compounds where  $W^1$  is  $N(R_{15})$ . Another group of compounds of Formula I includes compounds where  $R_{15}$  is independently any one of the following: H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl, including, but not limited to, lower alkyl, lower halogenated alkyl, or lower substituted alkyl. Surprisingly, compounds where W is attached at the five or six position have superior activity in the assays discussed herein compared to the other regioisomers. Another group of compounds of Formula I includes compounds where W is any one or more of the following: 5-benzofuranyl, 6-benzofuranyl, 5-1*H*-indolyl, 6-1*H*-indolyl, 5-benzothienyl, or 6-benzothienyl, any of which is optionally substituted at the carbon two or three position with any one of the following: lower alkyl, including but not limited to, methyl, ethyl, or isopropyl; lower halogenated alkyl including, but not limited to, trifluoromethyl, 1,1,1-trifluoroethyl, or 1,1,1-trifluoro-2,2-difluoroethyl; lower alkynyl including, but not limited to, ethynyl, or propyn-1-yl; halogen; cyano; aminocarbonyl; formyl; or acetyl. Surprisingly, we have found that the compounds having W be benzofuranyl have better residence time in the brain and offer other benefits. Furthermore, the bond from the carbonyl of the amide moiety should be attached to W at carbon five or six of the W moiety. Another group of compounds of Formula I includes compounds where W is 5-benzofuranyl or 6-benzofuranyl, any of which is optionally substituted at the carbon two or three position with any one of the following: lower alkyl, including but not limited to, methyl, ethyl, or isopropyl; lower halogenated alkyl including, but not limited to, trifluoromethyl, 1,1,1-trifluoroethyl, or 1,1,1-trifluoro-2,2-difluoroethyl; lower alkynyl including, but not limited to, ethynyl, or propyn-1-yl; halogen; cyano; aminocarbonyl; formyl; or acetyl.

Another group of compounds of Formula I includes compounds where  $R_1$  is H. Another group of compounds of Formula I includes compounds where  $R_1$  is any one of the following: alkyl, lower alkyl, halogenated alkyl, lower halogenated alkyl, cycloalkyl, substituted phenyl, or substituted naphthyl, including but not limited to, methyl, benzyl and the like.

Another group of compounds of Formula I includes compounds where  $R_2$  is H. Another group of compounds of Formula I includes compounds where  $R_2$  includes any one of the following: F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl,

cycloalkyl, or aryl. Another group of compounds of Formula I includes compounds where  $R_2$  includes any one of alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl, including, but not limited to, lower alkyl including methyl, lower halogenated alkyl, or lower substituted alkyl.

- 5 Another group of compounds of Formula I includes compounds where  $R_3$  is H. Another group of compounds of Formula I includes compounds where  $R_3$  is any one of the following: lower alkyl, lower substituted alkyl, or lower halogenated alkyl.

Another group of compounds of Formula I includes compounds where each  $R_4$  is H. Another group of compounds of Formula I includes compounds where each  $R_4$  independently includes any one of the following: H, F, Cl, Br, I, alkyl, lower alkyl, halogenated alkyl, lower halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, lower alkynyl, halogenated alkynyl, substituted alkynyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, lactam heterocycloalkyl, phenyl, substituted phenyl, aminocarbonyl, formyl, or acetyl,  $-OR_{10}$ ,  $-SR_{10}$ ,  $-SOR_{10}$ ,  $-SO_2R_{10}$ ,  $-NR_{10}C(O)R_5$ ,  $-NR_{10}C(O)R_6$ ,  $-NR_{10}C(O)R_8$ ,  $-NR_{10}C(O)R_{10}$ ,  $-N(R_{10})_2$ ,  $-NO_2$ ,  $-C(O)R_{10}$ ,  $-CN$ ,  $-C(O)_2R_{10}$ ,  $-C(O)NHR_{10}$ ,  $-SCN$ ,  $-S(O)N(R_{10})_2$ ,  $-S(O)_2NR_{10}R_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ ,  $R_5$ , or  $R_6$ . When  $R_4$  is  $-SOR_{10}$ ,  $-COR_{10}$ ,  $-SO_2R_{10}$ , or  $-CO_2R_{10}$  and  $R_{10}$  is heterocycle, halogenated heterocycle or heterocycle substituted with 1 substituent selected from  $R_{13}$ , a carbon with sufficient valency in the heterocycle is bonded to the carbon or sulfur; for example, but not limitation, if  $R_4$  were pyrrolidinylcarbonyl, it would not be pyrrolidin-1-ylcarbonyl because the carbonyl would be attached to an atom other than carbon.

- 25 Another group of compounds of Formula I includes compounds where each  $R_8$  is independently any one of the following: H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, phenyl, or phenyl substituted with 0-4 independently selected from F, Cl, Br, I, or  $R_9$ .

- 30 Another group of compounds of Formula I includes compounds where each  $R_{10}$  is independently any one of the following: H, alkyl, cycloalkyl, heterocycloalkyl, alkyl substituted with 1 substituent selected from  $R_{13}$ , cycloalkyl substituted with 1 substituent selected from  $R_{13}$ , heterocycloalkyl substituted with 1 substituent selected



from R<sub>13</sub>, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, phenyl, or substituted phenyl.

Another group of compounds of Formula I includes compounds where each R<sub>14</sub> is independently any one of the following: H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, F, Cl, Br, I, or a bond. When R<sub>14</sub> is a bond, the bond connects the moiety being R<sub>5</sub> to another moiety and does not make an unsaturated bond within the R<sub>5</sub> moiety. R<sub>14</sub> would only be a bond if no other carbon atom within R<sub>5</sub> allows for the bond between the R<sub>5</sub> moiety and the other moiety to which it is bonded.

One of ordinary skill in the art will recognize that where alkyl, halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, halogenated alkynyl, or substituted alkynyl is allowed, the following, respectively, are also allowed: lower alkyl, lower halogenated alkyl, lower substituted alkyl, lower alkenyl, lower halogenated alkenyl, lower substituted alkenyl, lower alkynyl, lower halogenated alkynyl, or lower substituted alkynyl.

Another group of compounds of Formula I includes any one or more or any combination of the following in a smaller group of compounds of the following as the free base or a pharmaceutically acceptable salt thereof:

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;

- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
5 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
10 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
15 *N*-5-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1*H*-indole-5-carboxamide; any of which is  
20 optionally substituted on the C-2 of quinuclidine with methyl in the *S* configuration,  
for example but not limitation, to give *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide.

Another group of compounds of Formula I includes any one or more or any combination of the following in a smaller group of compounds of the following as the  
25 free base or a pharmaceutically acceptable salt thereof:

- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
30 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,5-dicarboxamide;

- 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;  
 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
 5 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
 10 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
 15 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,6-dicarboxamide;  
 20 *N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-5-carboxamide;  
 25  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
 30 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
 2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;

- 2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
5 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
10 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
15 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
20 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1*H*-indole-5-carboxamide;
- 25 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
30 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;

- 2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
5 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
10 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
15 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,5-dicarboxamide;  
20 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1*H*-indole-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
25 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-5-carboxamide;  
30 *N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-5-carboxamide;  
5 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-6-carboxamide;  
10 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
15 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,5-dicarboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-6-carboxamide;  
20 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1*H*-indole-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1*H*-indole-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
25 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,6-dicarboxamide;  
30 *N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-6-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
 5 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-5-carboxamide;  
 10 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-6-carboxamide;  
 15 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,5-dicarboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-5-carboxamide;  
 20 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-1*H*-indole-6-carboxamide; or  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1*H*-indole-5-carboxamide.

The invention also concerns the synthesis of and isolation of stereospecific intermediates and final compounds. Specifically, the present invention concerns the stereospecific synthesis of (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine, or salts thereof.

- 25 Although there are known procedures for making 1-azabicyclo[3.2.1]octan-3-amine, separation of the different stereoisomers as described herein occurs without using a chiral HPLC separation procedure. The procedure within this invention results in an efficient selective synthesis of (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine.

- Another aspect of the present invention includes a method for making (3*R*,5*R*)-  
 30 1-azabicyclo[3.2.1]octan-3-amine or salt thereof. One process for producing (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine or a salt thereof, from (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate, comprises: the process of producing (5*R*)-3-oxo-1-

[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride from (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate;

the process of producing (5*R*)-1-azabicyclo[3.2.1]octan-3-one or a salt thereof from (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride;

5 and the process of producing (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine or a salt thereof from (5*R*)-1-azabicyclo[3.2.1]octan-3-one or a salt thereof.

Another process comprises: the process of producing (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate from (3*R*)-1-[(*S*)-1-phenethyl]-3-(cyanomethyl)pyrrolidine;

10 the process of producing (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride from (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate;

the process of producing (5*R*)-1-azabicyclo[3.2.1]octan-3-one or a salt thereof from (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride;

15 and the process of producing (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine or a salt thereof from (5*R*)-1-azabicyclo[3.2.1]octan-3-one or a salt thereof.

Another process comprises: the process of producing (3*S*)-1-[(*S*)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid from (*S*)-(-)- $\alpha$ -methyl benzylamine;

the process of isolating (3*S*)-1-[(*S*)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid from a racemic mixture using a precipitating solvent without causing the precipitation of other isomers, where the solvent can include a primary alcohol, including but not limited to methanol;

20 the process of producing (3*S*)-1-[(*S*)-1-phenethyl]-3-(hydroxymethyl)pyrrolidine from (3*S*)-1-[(*S*)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid;

the process of producing (3*S*)-1-[(*S*)-1-phenethyl]-3-(chloromethyl)pyrrolidine from (3*S*)-1-[(*S*)-1-phenethyl]-3-(hydroxymethyl)pyrrolidine;

the process of producing (3*R*)-1-[(*S*)-1-phenethyl]-3-(cyanomethyl)pyrrolidine from (3*S*)-1-[(*S*)-1-phenethyl]-3-(chloromethyl)pyrrolidine;

30 the process of producing (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate from (3*R*)-1-[(*S*)-1-phenethyl]-3-(cyanomethyl)pyrrolidine;



the process of producing (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride from (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate;

the process of producing (5*R*)-1-azabicyclo[3.2.1]octan-3-one or salt thereof  
5 from (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride;

and the process of producing (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine or salt thereof from (5*R*)-1-azabicyclo[3.2.1]octan-3-one or salt thereof.

Another process comprises: the process of producing (3*S*)-1-[(*S*)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid from (*S*)-(-)- $\alpha$ -methyl benzylamine;

10 the process of producing (3*S*)-1-[(*S*)-1-phenethyl]-3-(hydroxymethyl)pyrrolidine from (3*S*)-1-[(*S*)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid;

the process of producing (3*S*)-1-[(*S*)-1-phenethyl]-3-(chloromethyl)pyrrolidine from (3*S*)-1-[(*S*)-1-phenethyl]-3-(hydroxymethyl)pyrrolidine;

15 the process of producing (3*R*)-1-[(*S*)-1-phenethyl]-3-(cyanomethyl)pyrrolidine from (3*S*)-1-[(*S*)-1-phenethyl]-3-(chloromethyl)pyrrolidine;

the process of producing (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate from (3*R*)-1-[(*S*)-1-phenethyl]-3-(cyanomethyl)pyrrolidine;

the process of producing (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride from (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate;  
20

the process of producing (5*R*)-1-azabicyclo[3.2.1]octan-3-one or salt thereof from (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride;

and the process of producing (3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine or salt thereof from (5*R*)-1-azabicyclo[3.2.1]octan-3-one or salt thereof.  
25

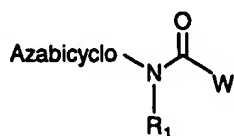
The present invention also includes the compounds of the present invention, pharmaceutical compositions containing the active compounds, and methods to treat the identified diseases.

Further aspects and embodiments of the invention may become apparent to  
30 those skilled in the art from a review of the following detailed description, taken in conjunction with the examples and the appended claims. While the invention is susceptible of embodiments in various forms, described hereafter are specific embodiments of the invention with the understanding that the present disclosure is

intended as illustrative, and is not intended to limit the invention to the specific embodiments described herein.

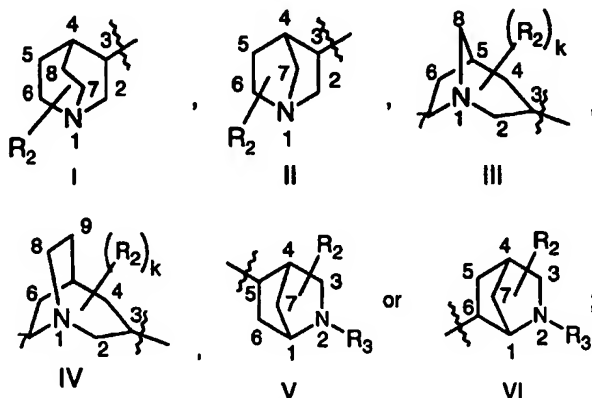
# DETAILED DESCRIPTION OF THE INVENTION

Surprisingly, we have found that compounds of Formula I:

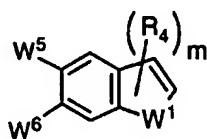


Formula I

wherein Azabicyclo is



W is



$\text{R}_1$  is H, alkyl, halogenated alkyl, cycloalkyl, substituted phenyl, or substituted naphthyl;

$\text{R}_2$  is H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

$k$  is 1 or 2, provided that when  $k$  is 2, each  $\text{R}_2$  is other than H;

$\text{R}_3$  is H, lower alkyl, lower substituted alkyl, or lower halogenated alkyl;

$\text{W}^1$  is O, S, or  $\text{N}(\text{R}_{15})$ ;

$\text{W}^5$  and  $\text{W}^6$  are independently H or a bond to the carbonyl of Formula I,

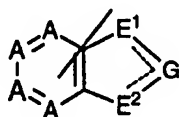
provided that only one of  $\text{W}^5$  and  $\text{W}^6$  is said bond and the other is H;

Each  $R_4$  is independently H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, halogenated alkynyl, substituted alkynyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, lactam  
 5 heterocycloalkyl, phenyl, substituted phenyl,  $-OR_{10}$ ,  $-SR_{10}$ ,  $-SOR_{10}$ ,  $-SO_2R_{10}$ ,  $-NR_{10}C(O)R_5$ ,  $-NR_{10}C(O)R_6$ ,  $-NR_{10}C(O)R_8$ ,  $-NR_{10}C(O)R_{10}$ ,  $-N(R_{10})_2$ ,  $-NO_2$ ,  $-C(O)R_{10}$ ,  $-CN$ ,  $-C(O)_2R_{10}$ ,  $-C(O)NHR_{10}$ ,  $-SCN$ ,  $-S(O)NHR_{10}$ ,  $-S(O)_2NHR_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ ,  $R_5$ , or  $R_6$ , provided that when  $R_4$  is  $-SO_{1-2}R_{10}$  or  $-CO_{1-2}R_{10}$  and  $R_{10}$  is heterocycle, halogenated heterocycle or heterocycle substituted with 1 substituent  
 10 selected from  $R_{13}$ , a carbon in the heterocycle is bonded to the carbon or sulfur;

$m$  is 1 or 2, provided that when  $m$  is 2 each  $R_4$  is other than H;

$R_5$  is a 5-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms independently selected from the group consisting of  $-O-$ ,  $=N-$ ,  $-N(R_{16})-$ , and  $-S-$ , and having 0-1 substituent selected from  $R_9$ , and further having 0-3  
 15 substituents independently selected from F, Cl, Br, or I,

or  $R_5$  is a 9-membered fused-ring moiety having a 6-membered ring fused to a 5-membered ring and having the formula



wherein each A is independently  $CR_{14}$  or N, provided that only up to one A is N,  $E^1$   
 20 and  $E^2$  are independently selected from  $CR_{14}$ , O, S, or  $NR_{16}$ , and G is  $CR_{14}$ , provided that  $R_{14}$  or  $R_{16}$  can be a bond when  $---$  forms a double bond and further provided that only one  $R_{14}$  or  $R_{16}$  can be a bond for bonding  $R_5$  to a moiety to which it is attached;

$R_6$  is a 6-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms selected from  $=N-$  and having 0-1 substituent selected from  $R_9$   
 25 and 0-3 substituent(s) independently selected from F, Cl, Br, or I,

or  $R_6$  is a 10-membered heteroaromatic bi-cyclic moiety containing within one or both rings 1-3 heteroatoms selected from  $=N-$ , including, but not limited to, quinolinyl or isoquinolinyl, each 10-membered fused-ring moiety having 0-1 substituent selected from  $R_9$ , and 0-3 substituent(s) independently selected from F, Cl,  
 30 Br, or I;

**R<sub>7</sub> is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, phenyl, or phenyl having 0-4 substituents independently selected from F, Cl, Br, I, and R<sub>9</sub>;**

Each **R<sub>8</sub>** is independently H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, phenyl, or phenyl substituted with 0-4 independently selected from F, Cl, Br, I, or R<sub>9</sub>;

**R<sub>9</sub> is alkyl, substituted alkyl, halogenated alky, -OR<sub>11</sub>, -CN, -NO<sub>2</sub>, -NR<sub>10</sub>R<sub>10</sub>;**

Each **R<sub>10</sub>** is independently H, alkyl, cycloalkyl, heterocycloalkyl, alkyl substituted with 1 substituent selected from R<sub>13</sub>, cycloalkyl substituted with 1 substituent selected from R<sub>13</sub>, heterocycloalkyl substituted with 1 substituent selected from R<sub>13</sub>, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, phenyl, or substituted phenyl;

Each **R<sub>11</sub>** is independently H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, or halogenated heterocycloalkyl;

**R<sub>12</sub> is -OR<sub>11</sub>, -SR<sub>11</sub>, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, or -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>;**

**R<sub>13</sub> is -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -SOR<sub>11</sub>, -SO<sub>2</sub>R<sub>11</sub>, -C(O)NR<sub>11</sub>R<sub>11</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>;**

Each **R<sub>14</sub>** is independently bond, H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, F, Cl, Br, I, or a bond, provided that the fused-ring moiety has 0-1 substituent selected from alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, or -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, and further provided that the fused-ring moiety has 0-3 substituent(s) selected from F, Cl, Br, or I;

$R_{15}$  is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

Each  $R_{16}$  is independently bond, H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

Aryl is phenyl, substituted phenyl, naphthyl, or substituted naphthyl;

Substituted phenyl is a phenyl either having 1-4 substituents independently selected from F, Cl, Br, or I, or having 1 substituent selected from  $R_{12}$  and 0-3 substituents independently selected from F, Cl, Br, or I;

Substituted naphthyl is a naphthalene moiety either having 1-4 substituents independently selected from F, Cl, Br, or I, or having 1 substituent selected from  $R_{12}$  and 0-3 substituents independently selected from F, Cl, Br, or I, where the substitution can be independently on either only one ring or both rings of said naphthalene moiety;

Alkyl is both straight- and branched-chain moieties having from 1-6 carbon atoms;

Lower alkyl is both straight- and branched-chain moieties having from 1-4 carbon atoms;

Halogenated alkyl is an alkyl moiety having from 1-6 carbon atoms and having 1 to  $(2n+1)$  substituent(s) independently selected from F, Cl, Br, or I where  $n$  is the maximum number of carbon atoms in the moiety;

Lower halogenated alkyl is an alkyl moiety having from 1-4 carbon atoms and having 1 to  $(2n+1)$  substituent(s) independently selected from F, Cl, Br, or I where  $n$  is the maximum number of carbon atoms in the moiety;

Substituted alkyl is an alkyl moiety from 1-6 carbon atoms and having 0-3 substituents independently selected from  $R_5$ ,  $R_6$ , F, Cl, Br, or I and further having 1 substituent selected from  $-OR_{10}$ ,  $-SR_{10}$ ,  $-NR_{10}R_{10}$ ,  $-C(O)R_{10}$ ,  $-C(O)NR_{10}R_{10}$ ,  $-CN$ ,  $-NR_{10}C(O)R_{10}$ ,  $-S(O)_2NR_{10}R_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ ,  $-NO_2$ , phenyl, or phenyl having 1 substituent selected from  $R_9$  and further having 0-3 substituents independently selected from F, Cl, Br, or I;

Lower substituted alkyl is lower alkyl having 0-3 substituents independently selected from F, Cl, Br, or I, and further having 1 substituent selected from  $-OR_{10}$ ,

-SR<sub>10</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -C(O)R<sub>10</sub>, -C(O)N(R<sub>10</sub>)<sub>2</sub>, -CN, -NR<sub>10</sub>C(O)R<sub>10</sub>, -S(O)<sub>2</sub>N(R<sub>10</sub>)<sub>2</sub>,  
-NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, -NO<sub>2</sub>, phenyl, R<sub>5</sub>, or R<sub>6</sub>,

wherein each R<sub>10</sub> is independently H, lower alkyl, cycloalkyl, heterocycloalkyl,  
or phenyl,

- 5        wherein any lower alkyl, cycloalkyl, heterocycloalkyl, or phenyl is optionally substituted with up to two halogens independently selected from F or Cl and up to one other substituent independently selected from -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>,  
and wherein each R<sub>11</sub> is independently H, lower alkyl, lower cycloalkyl,  
10    heterocycloalkyl, lower halogenated alkyl, lower halogenated cycloalkyl, or halogenated heterocycloalkyl;

Alkenyl is straight- and branched-chain moieties having from 2-6 carbon atoms and having at least one carbon-carbon double bond;

- Lower alkenyl is straight- and branched-chain moieties having from 2-4  
15    carbon atoms and having at least one carbon-carbon double bond;

Halogenated alkenyl is an unsaturated alkenyl moiety having from 2-6 carbon atoms and having 1 to (2n-1) substituent(s) independently selected from F, Cl, Br, or I where n is the maximum number of carbon atoms in the moiety;

- Lower halogenated alkenyl is an unsaturated alkenyl moiety having from 2-4  
20    carbon atoms and having 1 to (2n-1) substituent(s) independently selected from F, Cl, Br, or I where n is the maximum number of carbon atoms in the moiety;

- Substituted alkenyl is an unsaturated alkenyl moiety having from 2-6 carbon atoms and having 0-3 substituents independently selected from F, or Cl, and further having 1 substituent selected from R<sub>5</sub>, R<sub>6</sub>, -OR<sub>10</sub>, -SR<sub>10</sub>, -NR<sub>10</sub>R<sub>10</sub>, -C(O)R<sub>10</sub>,  
25    -C(O)NR<sub>10</sub>R<sub>10</sub>, -NR<sub>10</sub>C(O)R<sub>10</sub>, -S(O)<sub>2</sub>NR<sub>10</sub>R<sub>10</sub>, -NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, -CN, phenyl, or phenyl having 1 substituent selected from R<sub>9</sub>, and further having 0-3 substituents independently selected from F, Cl, Br, or I;

- Lower substituted alkenyl is lower alkenyl having 0-3 substituents independently selected from F, Cl, Br, or I, and further having 1 substituent selected  
30    from R<sub>5</sub>, R<sub>6</sub>, -CN, -OR<sub>10</sub>, -SR<sub>10</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -C(O)R<sub>10</sub>, -C(O)N(R<sub>10</sub>)<sub>2</sub>, -NR<sub>10</sub>C(O)R<sub>10</sub>, -S(O)<sub>2</sub>N(R<sub>10</sub>)<sub>2</sub>, -NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, -NO<sub>2</sub>, phenyl, R<sub>5</sub>, or R<sub>6</sub>,

wherein each R<sub>10</sub> is independently H, lower alkyl, cycloalkyl, heterocycloalkyl,  
or phenyl,

wherein any lower alkyl, cycloalkyl, heterocycloalkyl, or phenyl is optionally substituted with up to two halogens independently selected from F or Cl and up to one other substituent independently selected from -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>,

5 and wherein each R<sub>11</sub> is independently H, lower alkyl, lower cycloalkyl, heterocycloalkyl, lower halogenated alkyl, lower halogenated cycloalkyl, or halogenated heterocycloalkyl;

Alkynyl is straight- and branched-chained moieties having from 2-6 carbon atoms and having at least one carbon-carbon triple bond;

10 Lower alkynyl is straight- and branched-chained moieties having from 2-6 carbon atoms and having at least one carbon-carbon triple bond;

Halogenated alkynyl is an unsaturated alkynyl moiety having from 3-6 carbon atoms and having 1 to (2n-3) substituent(s) independently selected from F, Cl, Br, or I where n is the maximum number of carbon atoms in the moiety;

15 Lower halogenated alkynyl is an unsaturated alkynyl moiety having from 3-4 carbon atoms and having 1 to (2n-3) substituent(s) independently selected from F, Cl, Br, or I where n is the maximum number of carbon atoms in the moiety;

Substituted alkynyl is an unsaturated alkynyl moiety having from 3-6 carbon atoms and having 0-3 substituents independently selected from F, or Cl, and further  
20 having 1 substituent selected from R<sub>5</sub>, R<sub>6</sub>, -OR<sub>10</sub>, -SR<sub>10</sub>, -NR<sub>10</sub>R<sub>10</sub>, -C(O)R<sub>10</sub>, -C(O)NR<sub>10</sub>R<sub>10</sub>, -NR<sub>10</sub>C(O)R<sub>10</sub>, -S(O)<sub>2</sub>NR<sub>10</sub>R<sub>10</sub>, -NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, -CN, phenyl, or phenyl having 1 substituent selected from R<sub>9</sub>, and further having 0-3 substituents independently selected from F, Cl, Br, or I;

Lower substituted alkynyl is lower alkynyl having 0-3 substituents  
25 independently selected from F, or Cl, and further having 1 substituent selected from R<sub>5</sub>, R<sub>6</sub>, -OR<sub>10</sub>, -SR<sub>10</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -C(O)R<sub>10</sub>, -C(O)N(R<sub>10</sub>)<sub>2</sub>, -CN, -NR<sub>10</sub>C(O)R<sub>10</sub>, -S(O)<sub>2</sub>N(R<sub>10</sub>)<sub>2</sub>, -NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, -NO<sub>2</sub>, phenyl, R<sub>5</sub>, or R<sub>6</sub>,

wherein each R<sub>10</sub> is independently H, lower alkyl, cycloalkyl, heterocycloalkyl, or phenyl,

30 wherein any lower alkyl, cycloalkyl, heterocycloalkyl, or phenyl is optionally substituted with up to two halogens independently selected from F or Cl and up to one other substituent independently selected from -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>,

and wherein each  $R_{11}$  is independently H, lower alkyl, lower cycloalkyl, heterocycloalkyl, lower halogenated alkyl, lower halogenated cycloalkyl, or halogenated heterocycloalkyl;

Cycloalkyl is a cyclic alkyl moiety having from 3-6 carbon atoms;

5 Halogenated cycloalkyl is a cyclic moiety having from 3-6 carbon atoms and having 1-4 substituents independently selected from F, or Cl;

Substituted cycloalkyl is a cyclic moiety having from 3-6 carbon atoms and having 0-3 substituents independently selected from F, or Cl, and further having 1 substituent selected from  $-OR_{10}$ ,  $-SR_{10}$ ,  $-NR_{10}R_{10}$ ,  $-C(O)R_{10}$ ,  $-CN$ ,  $-C(O)NR_{10}R_{10}$ ,  
10  $-NR_{10}C(O)R_{10}$ ,  $-S(O)_2NR_{10}R_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ ,  $-NO_2$ , phenyl, or phenyl having 1 substituent selected from  $R_9$ , and further having 0-3 substituents independently selected from F, Cl, Br, or I;

Heterocycloalkyl is a cyclic moiety having 4-7 atoms with 1-2 atoms within the ring being  $-S-$ ,  $-N(R_7)-$ , or  $-O-$ ;

15 Halogenated heterocycloalkyl is a cyclic moiety having from 4-7 atoms with 1-2 atoms within the ring being  $-S-$ ,  $-N(R_7)-$ , or  $-O-$ , and having 1-4 substituents independently selected from F, or Cl;

Substituted heterocycloalkyl is a cyclic moiety having from 4-7 atoms with 1-2 atoms within the ring being  $-S-$ ,  $-N(R_7)-$ , or  $-O-$  and having 0-3 substituents  
20 independently selected from  $-F$ , or  $-Cl$ , and further having 1 substituent selected from  $R_5$ ,  $R_6$ ,  $-OR_{10}$ ,  $-SR_{10}$ ,  $-NR_{10}R_{10}$ ,  $-C(O)R_{10}$ ,  $-C(O)NR_{10}R_{10}$ ,  $-CN$ ,  $-NR_{10}C(O)R_{10}$ ,  $-NO_2$ ,  $-S(O)_2NR_{10}R_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ , phenyl, or phenyl having 1 substituent selected from  $R_9$  and further having 0-3 substituents independently selected from F, Cl, Br, or I;

Lactam heterocycloalkyl is a cyclic moiety having from 4-7 atoms with one  
25 atom being only nitrogen with the bond to the lactam heterocycloalkyl thru said atom being only nitrogen and having a  $=O$  on a carbon adjacent to said nitrogen, and having up to 1 additional ring atom being oxygen, sulfur, or nitrogen and further having 0-2 substituents selected from F, Cl, Br, I, or  $R_9$  where valency allows;

or pharmaceutical composition, pharmaceutically acceptable salt, racemic  
30 mixture, or pure enantiomer thereof useful to treat any one of or combination of cognitive and attention deficit symptoms of Alzheimer's, neurodegeneration associated with diseases such as Alzheimer's disease, pre-senile dementia (mild cognitive impairment), senile dementia, schizophrenia, psychosis, attention deficit



disorder, attention deficit hyperactivity disorder, mood and affective disorders, amyotrophic lateral sclerosis, borderline personality disorder, traumatic brain injury, behavioral and cognitive problems associated with brain tumors, AIDS dementia complex, dementia associated with Down's syndrome, dementia associated with Lewy  
5 Bodies, Huntington's disease, depression, general anxiety disorder, age-related macular degeneration, Parkinson's disease, tardive dyskinesia, Pick's disease, post traumatic stress disorder, dysregulation of food intake including bulimia and anorexia nervosa, withdrawal symptoms associated with smoking cessation and dependant drug cessation, Gilles de la Tourette's Syndrome, glaucoma, neurodegeneration associated  
10 with glaucoma, or symptoms associated with pain.

In another aspect, the invention includes methods of treating a mammal suffering from schizophrenia or psychosis by administering compounds of Formula I in conjunction with antipsychotic drugs. The compounds of Formula I and the antipsychotic drugs can be administered simultaneously or at separate intervals.  
15 When administered simultaneously the compounds of Formula I and the antipsychotic drugs can be incorporated into a single pharmaceutical composition. Alternatively, two separate compositions, i.e., one containing compounds of Formula I and the other containing antipsychotic drugs, can be administered simultaneously.

The present invention also includes the intermediates, the processes to make  
20 them and the active compounds of Formula I, pharmaceutical compositions including the active compounds, and methods to treat the identified diseases.

Abbreviations which are well known to one of ordinary skill in the art may be used (e.g., "Ph" for phenyl, "Me" for methyl, "Et" for ethyl, "h" or "hr" for hour or hours, min for minute or minutes, and "rt" or "RT" for room temperature).

25 All temperatures are in degrees Centigrade.

Room temperature is within the range of 15-25 degrees Celsius.

AChR refers to acetylcholine receptor.

nAChR refers to nicotinic acetylcholine receptor.

Pre-senile dementia is also known as mild cognitive impairment.

30 5HT<sub>3</sub>R refers to the serotonin-type 3 receptor.

$\alpha$ -btX refers to  $\alpha$ -bungarotoxin.

FLIPR refers to a device marketed by Molecular Devices, Inc. designed to precisely measure cellular fluorescence in a high throughput whole-cell assay. (Schroeder et. al., *J. Biomolecular Screening*, 1(2), p 75-80, 1996).

TLC refers to thin-layer chromatography.

5 HPLC refers to high pressure liquid chromatography.

MeOH refers to methanol.

EtOH refers to ethanol.

IPA refers to isopropyl alcohol.

THF refers to tetrahydrofuran.

10 DMSO refers to dimethylsulfoxide.

DMF refers to *N,N*-dimethylformamide.

EtOAc refers to ethyl acetate.

TMS refers to tetramethylsilane.

TEA refers to triethylamine.

15 DIEA refers to *N,N*-diisopropylethylamine.

DIA refers to diisopropylamine.

MLA refers to methyllycaconitine.

Ether refers to diethyl ether.

20 HATU refers to O-(7-azabenzotriazol-1-yl)-*N,N,N',N'*-tetramethyluronium hexafluorophosphate.

DBU refers to 1,8-diazobicyclo[5.4.0]undec-7-one.

CDI refers to carbonyl diimidazole.

NMO refers to *N*-methylmorpholine-*N*-oxide.

TPAP refers to tetrapropylammonium perruthenate.

25 Halogen is F, Cl, Br, or I.

Na<sub>2</sub>SO<sub>4</sub> refers to sodium sulfate.

K<sub>2</sub>CO<sub>3</sub> refers to potassium carbonate.

MgSO<sub>4</sub> refers to magnesium sulfate.

When Na<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, or MgSO<sub>4</sub> is used as a drying agent, it is anhydrous.

30 The carbon atom content of various hydrocarbon-containing moieties is indicated by a prefix designating the minimum and maximum number of carbon atoms in the moiety, i.e., the prefix C<sub>i-j</sub> indicates a moiety of the integer "i" to the

integer "j" carbon atoms, inclusive. Thus, for example, C<sub>1-6</sub> alkyl refers to alkyl of one to six carbon atoms.

Non-inclusive examples of heteroaryl compounds that fall within the definition of R<sub>5</sub> and R<sub>6</sub> include, but are not limited to, thienyl, benzothienyl, pyridyl, thiazolyl, quinolyl, pyrazinyl, pyrimidyl, imidazolyl, furanyl, benzofuranyl, benzothiazolyl, isothiazolyl, benzisothiazolyl, benzisoxazolyl, benzimidazolyl, indolyl, benzoxazolyl, pyrazolyl, triazolyl, tetrazolyl, isoxazolyl, oxazolyl, pyrrolyl, isoquinolyl, cinnolyl, indazolyl, indolizyl, phthalazyl, pyridazyl, triazinyl, isoindolyl, purinyl, oxadiazolyl, furazanyl, benzofurazanyl, benzothiophenyl, benzothiazolyl, quinazolinyl, quinoxalinyl, naphthridinyl, and furopyridinyl.

Non-inclusive examples of heterocycloalkyl include, but are not limited to, tetrahydrofurano, tetrahydropyrano, morpholino, pyrrolidino, piperidino, piperazine, azetidino, azetidinono, oxindolo, dihydroimidazolo, and pyrrolidinono

Mammal denotes human and other mammals.

Brine refers to an aqueous saturated sodium chloride solution.

Equ means molar equivalents.

IR refers to infrared spectroscopy.

Lv refers to leaving groups within a molecule, including Cl, OH, or mixed anhydride.

NMR refers to nuclear (proton) magnetic resonance spectroscopy, chemical shifts are reported in ppm ( $\delta$ ) downfield from TMS.

MS refers to mass spectrometry expressed as m/e or mass/charge unit. HRMS refers to high resolution mass spectrometry expressed as m/e or mass/charge unit.

[M+H]<sup>+</sup> refers to an ion composed of the parent plus a proton. [M-H]<sup>-</sup> refers to an ion composed of the parent minus a proton. [M+Na]<sup>+</sup> refers to an ion composed of the parent plus a sodium ion. [M+K]<sup>+</sup> refers to an ion composed of the parent plus a potassium ion. EI refers to electron impact. ESI refers to electrospray ionization. CI refers to chemical ionization. FAB refers to fast atom bombardment.

Amino protecting group includes, but is not limited to, carbobenzyloxy (CBz), *tert* butoxy carbonyl (BOC) and the like. Examples of other suitable amino protecting groups are known to person skilled in the art and can be found in "Protective Groups in Organic synthesis," 3rd Edition, authored by Theodora Greene and Peter Wuts.

Compounds of the present invention may be in the form of pharmaceutically acceptable salts. The term "pharmaceutically acceptable salts" refers to salts prepared from pharmaceutically acceptable non-toxic bases including inorganic bases and organic bases, and salts prepared from inorganic acids, and organic acids. Salts derived from inorganic bases include aluminum, ammonium, calcium, ferric, ferrous, lithium, magnesium, potassium, sodium, zinc, and the like. Salts derived from pharmaceutically acceptable organic non-toxic bases include salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines, such as arginine, betaine, caffeine, choline, N, N-dibenzylethylenediamine, diethylamine, 2-diethylaminoethanol, 2-dimethylaminoethanol, ethanolamine, ethylenediamine, N-ethylmorpholine, N-ethylpiperidine, glucamine, glucosamine, histidine, hydrabamine, isopropylamine, lysine, methylglucamine, morpholine, piperazine, piperidine, polyamine resins, procaine, purines, theobromine, triethylamine, trimethylamine, tripropylamine, and the like. Salts derived from inorganic acids include salts of hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid, phosphoric acid, phosphorous acid and the like. Salts derived from pharmaceutically acceptable organic non-toxic acids include salts of C<sub>1-6</sub> alkyl carboxylic acids, di-carboxylic acids, and tri-carboxylic acids such as acetic acid, propionic acid, fumaric acid, succinic acid, tartaric acid, maleic acid, adipic acid, and citric acid, and aryl and alkyl sulfonic acids such as toluene sulfonic acids and the like.

By the term "effective amount" of a compound as provided herein is meant a nontoxic but sufficient amount of the compound(s) to provide the desired effect. As pointed out below, the exact amount required will vary from subject to subject, depending on the species, age, and general condition of the subject, the severity of the disease that is being treated, the particular compound(s) used, the mode of administration, and the like. Thus, it is not possible to specify an exact "effective amount." However, an appropriate effective amount may be determined by one of ordinary skill in the art using only routine experimentation.

The amount of therapeutically effective compound(s) that is administered and the dosage regimen for treating a disease condition with the compounds and/or compositions of this invention depends on a variety of factors, including the age, weight, sex and medical condition of the subject, the severity of the disease, the route

and frequency of administration, and the particular compound(s) employed, and thus may vary widely. The compositions contain well known carriers and excipients in addition to a therapeutically effective amount of compounds of Formula I. The pharmaceutical compositions may contain active ingredient in the range of about  
5 0.001 to 100 mg/kg/day for an adult, preferably in the range of about 0.1 to 50 mg/kg/day for an adult. A total daily dose of about 1 to 1000 mg of active ingredient may be appropriate for an adult. The daily dose can be administered in one to four doses per day.

In addition to the compound(s) of Formula I, the composition for therapeutic  
10 use may also comprise one or more non-toxic, pharmaceutically acceptable carrier materials or excipients. The term "carrier" material or "excipient" herein means any substance, not itself a therapeutic agent, used as a carrier and/or diluent and/or adjuvant, or vehicle for delivery of a therapeutic agent to a subject or added to a pharmaceutical composition to improve its handling or storage properties or to permit  
15 or facilitate formation of a dose unit of the composition into a discrete article such as a capsule or tablet suitable for oral administration. Excipients can include, by way of illustration and not limitation, diluents, disintegrants, binding agents, adhesives, wetting agents, polymers, lubricants, glidants, substances added to mask or counteract a disagreeable taste or odor, flavors, dyes, fragrances, and substances added to  
20 improve appearance of the composition. Acceptable excipients include lactose, sucrose, starch powder, cellulose esters of alkanolic acids, cellulose alkyl esters, talc, stearic acid, magnesium stearate, magnesium oxide, sodium and calcium salts of phosphoric and sulfuric acids, gelatin, acacia gum, sodium alginate, polyvinylpyrrolidone, and/or polyvinyl alcohol, and then tableted or encapsulated for  
25 convenient administration. Such capsules or tablets may contain a controlled-release formulation as may be provided in a dispersion of active compound in hydroxypropylmethyl cellulose, or other methods known to those skilled in the art. For oral administration, the pharmaceutical composition may be in the form of, for example, a tablet, capsule, suspension or liquid. If desired, other active ingredients may be  
30 included in the composition.

In addition to the oral dosing, noted above, the compositions of the present invention may be administered by any suitable route, in the form of a pharmaceutical composition adapted to such a route, and in a dose effective for the treatment

intended. The compositions may, for example, be administered parenterally, e.g., intravascularly, intraperitoneally, subcutaneously, or intramuscularly. For parenteral administration, saline solution, dextrose solution, or water may be used as a suitable carrier. Formulations for parenteral administration may be in the form of aqueous or non-aqueous isotonic sterile injection solutions or suspensions. These solutions and suspensions may be prepared from sterile powders or granules having one or more of the carriers or diluents mentioned for use in the formulations for oral administration. The compounds may be dissolved in water, polyethylene glycol, propylene glycol, EtOH, corn oil, cottonseed oil, peanut oil, sesame oil, benzyl alcohol, sodium chloride, and/or various buffers. Other adjuvants and modes of administration are well and widely known in the pharmaceutical art.

The serotonin type 3 receptor (5HT<sub>3</sub>R) is a member of a superfamily of ligand-gated ion channels, which includes the muscle and neuronal nAChR, the glycine receptor, and the  $\gamma$ -aminobutyric acid type A receptor. Like the other members of this receptor superfamily, the 5HT<sub>3</sub>R exhibits a large degree of sequence homology with  $\alpha 7$  nAChR but functionally the two ligand-gated ion channels are very different. For example,  $\alpha 7$  nAChR is rapidly inactivated, is highly permeable to calcium and is activated by acetylcholine and nicotine. On the other hand, 5HT<sub>3</sub>R is inactivated slowly, is relatively impermeable to calcium and is activated by serotonin. These experiments suggest that the  $\alpha 7$  nAChR and 5HT<sub>3</sub>R proteins have some degree of homology, but function very differently. Indeed the pharmacology of the channels is very different. For example, Ondansetron, a highly selective 5HT<sub>3</sub>R antagonist, has little activity at the  $\alpha 7$  nAChR. The converse is also true. For example, GTS-21, a highly selective  $\alpha 7$  nAChR agonist, has little activity at the 5HT<sub>3</sub>R.

$\alpha 7$  nAChR is a ligand-gated Ca<sup>++</sup> channel formed by a homopentamer of  $\alpha 7$  subunits. Previous studies have established that  $\alpha$ -bungarotoxin ( $\alpha$ -btx) binds selectively to this homopentameric,  $\alpha 7$  nAChR subtype, and that  $\alpha 7$  nAChR has a high affinity binding site for both  $\alpha$ -btx and methyllycaconitine (MLA).  $\alpha 7$  nAChR is expressed at high levels in the hippocampus, ventral tegmental area and ascending cholinergic projections from nucleus basalis to thalamocortical areas.  $\alpha 7$  nAChR agonists increase neurotransmitter release, and increase cognition, arousal, attention, learning and memory.

Data from human and animal pharmacological studies establish that nicotinic cholinergic neuronal pathways control many important aspects of cognitive function including attention, learning and memory (Levin, E.D., *Psychopharmacology*, 108:417-31, 1992; Levin, E.D. and Simon B.B., *Psychopharmacology*, 138:217-30, 1998). For example, it is well known that nicotine increases cognition and attention in humans. ABT-418, a compound that activates  $\alpha 4\beta 2$  and  $\alpha 7$  nAChR, improves cognition and attention in clinical trials of Alzheimer's disease and attention-deficit disorders (Potter, A. et. al., *Psychopharmacology (Berl.)*, 142(4):334-42, Mar. 1999; Wilens, T. E. et. al., *Am. J. Psychiatry*, 156(12):1931-7, Dec. 1999). It is also clear that nicotine and selective but weak  $\alpha 7$  nAChR agonists increase cognition and attention in rodents and non-human primates.

Schizophrenia is a complex multifactorial illness caused by genetic and non-genetic risk factors that produce a constellation of positive and negative symptoms. The positive symptoms include delusions and hallucinations and the negative symptoms include deficits in affect, attention, cognition and information processing. No single biological element has emerged as a dominant pathogenic factor in this disease. Indeed, it is likely that schizophrenia is a syndrome that is produced by the combination of many low penetrance risk factors. Pharmacological studies established that dopamine receptor antagonists are efficacious in treating the overt psychotic features (positive symptoms) of schizophrenia such as hallucinations and delusions. Clozapine, an "atypical" antipsychotic drug, is novel because it is effective in treating both the positive and some of the negative symptoms of this disease. Clozapine's utility as a drug is greatly limited because continued use leads to an increased risk of agranulocytosis and seizure. No other antipsychotic drug is effective in treating the negative symptoms of schizophrenia. This is significant because the restoration of cognitive functioning is the best predictor of a successful clinical and functional outcome of schizophrenic patients (Green, M.F., *Am J Psychiatry*, 153:321-30, 1996). By extension, it is clear that better drugs are needed to treat the cognitive disorders of schizophrenia in order to restore a better state of mental health to patients with this disorder.

One aspect of the cognitive deficit of schizophrenia can be measured by using the auditory event-related potential (P50) test of sensory gating. In this test, electroencephalographic (EEG) recordings of neuronal activity of the hippocampus

are used to measure the subject's response to a series of auditory "clicks" (Adler, L.E. et. al., *Biol. Psychiatry*, 46:8-18, 1999). Normal individuals respond to the first click with greater degree than to the second click. In general, schizophrenics and schizotypal patients respond to both clicks nearly the same (Cullum, C.M. et. al.,  
5 *Schizophr. Res.*, 10:131-41, 1993). These data reflect a schizophrenic's inability to "filter" or ignore unimportant information. The sensory gating deficit appears to be one of the key pathological features of this disease (Cadenhead, K.S. et. al., *Am. J. Psychiatry*, 157:55-9, 2000). Multiple studies show that nicotine normalizes the sensory deficit of schizophrenia (Adler, L.E. et. al., *Am. J. Psychiatry*, 150:1856-61,  
10 1993). Pharmacological studies indicate that nicotine's effect on sensory gating is via the  $\alpha 7$  nAChR (Adler, L.E. et. al., *Schizophr. Bull.*, 24:189-202, 1998). Indeed, the biochemical data indicate that schizophrenics have 50% fewer of  $\alpha 7$  nAChR receptors in the hippocampus, thus giving a rationale to partial loss of  $\alpha 7$  nAChR functionality (Freedman, R. et. al., *Biol. Psychiatry*, 38:22-33, 1995). Interestingly, genetic data  
15 indicate that a polymorphism in the promoter region of the  $\alpha 7$  nAChR gene is strongly associated with the sensory gating deficit in schizophrenia (Freedman, R. et. al., *Proc. Nat'l Acad. Sci. USA*, 94(2):587-92, 1997; Myles-Worsley, M. et. al., *Am. J. Med. Genet*, 88(5):544-50, 1999). To date, no mutation in the coding region of the  $\alpha 7$  nAChR has been identified. Thus, schizophrenics express the same  $\alpha 7$  nAChR as  
20 non-schizophrenics.

Selective  $\alpha 7$  nAChR agonists may be found using a functional assay on FLIPR (see WO 00/73431 A2). FLIPR is designed to read the fluorescent signal from each well of a 96 or 384 well plate as fast as twice a second for up to 30 minutes. This assay may be used to accurately measure the functional pharmacology of  $\alpha 7$  nAChR  
25 and 5HT<sub>3</sub>R. To conduct such an assay, one uses cell lines that expressed functional forms of the  $\alpha 7$  nAChR using the  $\alpha 7/5$ -HT<sub>3</sub> channel as the drug target and cell lines that expressed functional 5HT<sub>3</sub>R. In both cases, the ligand-gated ion channel was expressed in SH-EP1 cells. Both ion channels can produce robust signal in the FLIPR assay.

30 The compounds of the present invention are  $\alpha 7$  nAChR agonists and may be used to treat a wide variety of diseases. For example, they may be used in treating schizophrenia, or psychosis.



Schizophrenia is a disease having multiple aspects. Currently available drugs are generally aimed at controlling the positive aspects of schizophrenia, such as delusions. One drug, Clozapine, is aimed at a broader spectrum of symptoms associated with schizophrenia. This drug has many side effects and is thus not  
5 suitable for many patients. Thus, there is a need for a drug to treat the cognitive and attention deficits associated with schizophrenia. Similarly, there is a need for a drug to treat the cognitive and attention deficits associated with schizoaffective disorders, or similar symptoms found in the relatives of schizophrenic patients.

Psychosis is a mental disorder characterized by gross impairment in the  
10 patient's perception of reality. The patient may suffer from delusions, and hallucinations, and may be incoherent in speech. His behavior may be agitated and is often incomprehensible to those around him. In the past, the term psychosis has been applied to many conditions that do not meet the stricter definition given above. For example, mood disorders were named as psychoses.

15 There are a variety of antipsychotic drugs. The conventional antipsychotic drugs include Chlorpromazine, Fluphenazine, Haloperidol, Loxapine, Mesoridazine, Molindone, Perphenazine, Pimozide, Thioridazine, Thiothixene, and Trifluoperazine. These drugs all have an affinity for the dopamine 2 receptor.

These conventional antipsychotic drugs have several side effects, including  
20 sedation, weight gain, tremors, elevated prolactin levels, akathisia (motor restlessness), dystonia and muscle stiffness. These drugs may also cause tardive dyskinesia. Unfortunately, only about 70% of patients with schizophrenia respond to conventional antipsychotic drugs. For these patients, atypical antipsychotic drugs are available.

25 Atypical antipsychotic drugs generally are able to alleviate positive symptoms of psychosis while also improving negative symptoms of the psychosis to a greater degree than conventional antipsychotics. These drugs may improve neurocognitive deficits. Extrapyramidal (motor) side effects are not as likely to occur with the atypical antipsychotic drugs, and thus, these atypical antipsychotic drugs have a lower  
30 risk of producing tardive dyskinesia. Finally these atypical antipsychotic drugs cause little or no elevation of prolactin. Unfortunately, these drugs are not free of side effects. Although these drugs each produce different side effects, as a group the side effects include: agranulocytosis; increased risk of seizures, weight gain, somnolence,

dizziness, tachycardia, decreased ejaculatory volume, and mild prolongation of QTc interval.

In a combination therapy to treat multiple symptoms of diseases such as schizophrenia, the compounds of Formula I and the anti-psychotic drugs can be administered simultaneously or at separate intervals. When administered simultaneously the compounds of Formula I and the anti-psychotic drugs can be incorporated into a single pharmaceutical composition, e.g., a pharmaceutical combination therapy composition. Alternatively, two separate compositions, i.e., one containing compounds of Formula I and the other containing anti-psychotic drugs, can be administered simultaneously. Examples of anti-psychotic drugs, in addition to those listed above, include, but are not limited to, Thorazine, Mellaril, Trilafon, Navane, Stelazine, Permitil, Prolixin, Risperdal, Zyprexa, Seroquel, ZELDOX, Acetophenazine, Carphenazine, Chlorprothixene, Droperidol, Loxapine, Mesoridazine, Molindone, Ondansetron, Pimozide, Prochlorperazine, and Promazine.

A pharmaceutical combination therapy composition can include therapeutically effective amounts of the compounds of Formula I and a therapeutically effective amount of anti-psychotic drugs. These compositions may be formulated with common excipients, diluents or carriers, and compressed into tablets, or formulated elixirs or solutions for convenient oral administration or administered by intramuscular intravenous routes. The compounds can be administered rectally, topically, orally, sublingually, or parenterally and maybe formulated as sustained relief dosage forms and the like.

When separately administered, therapeutically effective amounts of compositions containing compounds of Formula I and anti-psychotic drugs are administered on a different schedule. One may be administered before the other as long as the time between the two administrations falls within a therapeutically effective interval. A therapeutically effective interval is a period of time beginning when one of either (a) the compounds of Formula I, or (b) the anti-psychotic drugs is administered to a human and ending at the limit of the beneficial effect in the treatment of schizophrenia or psychosis of the combination of (a) and (b). The methods of administration of the compounds of Formula I and the anti-psychotic drugs may vary. Thus, either agent or both agents may be administered rectally, topically, orally, sublingually, or parenterally.

As discussed, the compounds of the present invention are  $\alpha 7$  nAChR agonists. Therefore, as another aspect of the present invention, the compounds of the present invention may be used to treat a variety of diseases including cognitive and attention  
5 deficit symptoms of Alzheimer's, neurodegeneration associated with diseases such as Alzheimer's disease, pre-senile dementia (also known as mild cognitive impairment), and senile dementia.

Alzheimer's disease has many aspects, including cognitive and attention deficits. Currently, these deficits are treated with cholinesterase inhibitors. These  
10 inhibitors slow the break down of acetylcholine, and thereby provide a general nonspecific increase in the activity of the cholinergic nervous system. Since the drugs are nonspecific, they have a wide variety of side effects. Thus, there is a need for a drug that stimulates a portion of the cholinergic pathways and thereby provides improvement in the cognitive and attention deficits associated with Alzheimer's  
15 disease without the side effects created by nonspecific stimulation of the cholinergic pathways.

Neurodegeneration is a common problem associated with diseases such as Alzheimer's disease. While the current drugs treat some of the symptoms of this disease, they do not control the underlying pathology of the disease. Accordingly, it  
20 would be desirable to provide a drug that can slow the progress of Alzheimer's disease.

Pre-senile dementia (mild cognitive impairment) concerns memory impairment rather than attention deficit problems and otherwise unimpaired cognitive functioning. Mild cognitive impairment is distinguished from senile dementia in that  
25 mild cognitive impairment involves a more persistent and troublesome problem of memory loss for the age of the patient. There currently is no medication specifically identified for treatment of mild cognitive impairment, due somewhat to the newness of identifying the disease. Therefore, there is a need for a drug to treat the memory problems associated with mild cognitive impairment.

30 Senile dementia is not a single disease state. However, the conditions classified under this name frequently include cognitive and attention deficits. Generally, these deficits are not treated. Accordingly, there is a need for a drug that

provides improvement in the cognitive and attention deficits associated with senile dementia.

As discussed, the compounds of the present invention are  $\alpha 7$  nAChR agonists.

5 Therefore, yet other diseases to be treated with compounds of the present invention include treating the cognitive and attention deficits as well as the neurodegeneration associated with any one or more or combination of the following: attention deficit disorder, attention deficit hyperactivity disorder, depression, anxiety, general anxiety disorder, post traumatic stress disorder, mood and affective disorders, amyotrophic  
10 lateral sclerosis, borderline personality disorder, traumatic brain injury, behavioral and cognitive problems associated with brain tumors, AIDS dementia complex, dementia associated with Down's syndrome, dementia associated with Lewy Bodies, Huntington's disease, Parkinson's disease, tardive dyskinesia, Pick's disease, dysregulation of food intake including bulimia and anorexia nervosa, withdrawal  
15 symptoms associated with smoking cessation and dependant drug cessation, Gilles de la Tourette's Syndrome, age-related macular degeneration, glaucoma, neurodegeneration associated with glaucoma, or symptoms associated with pain.

Attention deficit disorder is generally treated with methylphenidate, an amphetamine-like molecule that has some potential for abuse. Accordingly, it would  
20 be desirable to provide a drug that treats attention deficit disorder while having fewer side effects than the currently used drug.

Attention deficit hyperactivity disorder, otherwise known as ADHD, is a neurobehavioral disorder affecting 3-5% of all American children. ADHD concerns cognitive alone or both cognitive and behavioral actions by interfering with a person's  
25 ability to stay on a task and to exercise age-appropriate inhibition. Several types of ADHD exist: a predominantly inattentive subtype, a predominantly hyperactive-impulsive subtype, and a combined subtype. Treatment may include medications such as methylphenidate, dextroamphetamine, or pemoline, which act to decrease impulsivity and hyperactivity and to increase attention. No "cure" for ADHD  
30 currently exists. Children with the disorder seldom outgrow it; therefore, there is a need for appropriate medicaments.

Depression is a mood disorder of varying lengths of normally several months to more than two years and of varying degrees of feelings involving sadness, despair,

and discouragement. The heterocyclic antidepressants (HCA's) are currently the largest class of antidepressants, but monoamine oxidase inhibitors (MAOI's) are used in particular types of depression. Common side effects from HCA's are sedation and weight gain. In elderly patients with organic brain disease, the side effects from

5 HCA's can also include seizures and behavioral symptoms. The main side effects from using MAOI's occur from dietary and drug interactions. Therefore, agents with fewer side effects would be useful.

Anxiety disorders (disorders with prominent anxiety or phobic avoidance), represent an area of unmet medical needs in the treatment of psychiatric illness. See

10 Diagnostic & Statistical Manual of Mental Disorders, IV (1994), pp 393-394, for various disease forms of anxiety.

General anxiety disorder (GAD) occurs when a person worries about things such as family, health, or work when there is no reason to worry and is unable not to worry. About 3 to 4% of the U.S. population has GAD during the course of a year.

15 GAD most often strikes people in childhood or adolescence, but can begin in adulthood, too. It affects women more often than men. Currently, treatment involves cognitive-behavioral therapy, relaxation techniques, and biofeedback to control muscle tension and medications such as benzodiazepines, imipramine, and buspirone. These drugs are effective but all have side-effect liabilities. Therefore, there is a need

20 of a pharmaceutical agent to address the symptoms with fewer side effects.

Anxiety also includes post-traumatic stress disorder (PTSD), which is a form of anxiety triggered by memories of a traumatic event that directly affected the patient or that the patient may have witnessed. The disorder commonly affects survivors of traumatic events including sexual assault, physical assault, war, torture, natural

25 disasters, an automobile accident, an airplane crash, a hostage situation, or a death camp. The affliction also can affect rescue workers at an airplane crash or a mass shooting, someone who witnessed a tragic accident or someone who has unexpectedly lost a loved one. Treatment for PTSD includes cognitive-behavioral therapy, group psychotherapy, and medications such as Clonazepam, Lorazepam and selective

30 serotonin-reuptake inhibitors such as Fluoxetine, Sertraline, Paroxetine, Citalopram and Fluvoxamine. These medications help control anxiety as well as depression. Various forms of exposure therapy (such as systemic desensitization and imaginal flooding) have all been used with PTSD patients. Exposure treatment for PTSD

involves repeated reliving of the trauma, under controlled conditions, with the aim of facilitating the processing of the trauma. Therefore, there is a need for better pharmaceutical agents to treat post traumatic stress disorder.

Mood and affective disorders fall within a large group of diseases, including  
5 monopolar depression and bi-polar mood disorder. These diseases are treated with three major classes of compounds. The first group is the heterocyclic antidepressant (HCA's). This group includes the well-known tricyclic antidepressants. The second group of compounds used to treat mood disorders is the monoamine oxidase inhibitors (MAOI's) that are used in particular types of diseases. The third drug is lithium.  
10 Common side effects from HCA's are sedation and weight gain. In elderly patients with organic brain disease, the side effects of HCA's can also include seizures and behavioral symptoms. The main side effects from using MAOI's occur from dietary and drug interactions. Benign side effects from the use of lithium include, but are not limited to, weight gain, nausea, diarrhea, polyuria, polydipsia, and tremor. Toxic side  
15 effects from lithium can include persistent headache, mental confusion, and may reach seizures and cardiac arrhythmias. Therefore, agents with less side effects or interactions with food or other medications would be useful.

Borderline personality disorder, although not as well known as bipolar disorder, is more common. People having borderline personality disorder suffer from  
20 a disorder of emotion regulation. Pharmaceutical agents are used to treat specific symptoms, such as depression or thinking distortions.

Acquired immune deficiency syndrome (AIDS) results from an infection with the human immunodeficiency virus (HIV). This virus attacks selected cells and impairs the proper function of the immune, nervous, and other systems. HIV infection  
25 can cause other problems such as, but not limited to, difficulties in thinking, otherwise known as AIDS dementia complex. Therefore, there is a need to drugs to relieve the confusion and mental decline of persons with AIDS.

Amyotrophic lateral sclerosis, also known as Lou Gehrig's disease, belongs to a class of disorders known as motor neuron diseases wherein specific nerve cells in  
30 the brain and spinal cord gradually degenerate to negatively affect the control of voluntary movement. Currently, there is no cure for amyotrophic lateral sclerosis although patients may receive treatment from some of their symptoms and although

Riluzole has been shown to prolong the survival of patients. Therefore, there is a need for a pharmaceutical agent to treat this disease.

Traumatic brain injury occurs when the brain is damaged from a sudden physical assault on the head. Symptoms of the traumatic brain injury include  
5 confusion and other cognitive problems. Therefore, there is a need to address the symptoms of confusion and other cognitive problems.

Brain tumors are abnormal growths of tissue found inside of the skull. Symptoms of brain tumors include behavioral and cognitive problems. Surgery, radiation, and chemotherapy are used to treat the tumor, but other agents are necessary  
10 to address associated symptoms. Therefore, there is a need to address the symptoms of behavioral and cognitive problems.

Persons with Down's syndrome have in all or at least some of their cells an extra, critical portion of the number 21 chromosome. Adults who have Down's syndrome are known to be at risk for Alzheimer-type dementia. Currently, there is no  
15 proven treatment for Down's syndrome. Therefore, there is a need to address the dementia associated with Down's syndrome.

Genetically programmed degeneration of neurons in certain areas of the brain cause Huntington's disease. Early symptoms of Huntington's disease include mood swings, or trouble learning new things or remembering a fact. Most drugs used to  
20 treat the symptoms of Huntington's disease have side effects such as fatigue, restlessness, or hyperexcitability. Currently, there is no treatment to stop or reverse the progression of Huntington's disease. Therefore, there is a need of a pharmaceutical agent to address the symptoms with fewer side effects.

Dementia with Lewy Bodies is a neurodegenerative disorder involving  
25 abnormal structures known as Lewy bodies found in certain areas of the brain. Symptoms of dementia with Lewy bodies include, but are not limited to, fluctuating cognitive impairment with episodic delirium. Currently, treatment concerns addressing the parkinsonian and psychiatric symptoms. However, medicine to control tremors or loss of muscle movement may actually accentuate the underlying disease of  
30 dementia with Lewy bodies. Therefore, there is a need of a pharmaceutical agent to treat dementia with Lewy bodies.

Parkinson's disease is a neurological disorder characterized by tremor, hypokinesia, and muscular rigidity. Currently, there is no treatment to stop the

progression of the disease. Therefore, there is a need of a pharmaceutical agent to address Parkinson's.

Tardive dyskinesia is associated with the use of conventional antipsychotic drugs. This disease is characterized by involuntary movements most often manifested by puckering of the lips and tongue and/or writhing of the arms or legs. The incidence of tardive dyskinesia is about 5% per year of drug exposure among patients taking conventional antipsychotic drugs. In about 2% of persons with the disease, tardive dyskinesia is severely disfiguring. Currently, there is no generalized treatment for tardive dyskinesia. Furthermore, the removal of the effect-causing drugs is not always an option due to underlying problems. Therefore, there is a need for a pharmaceutical agent to address the symptoms of tardive dyskinesia.

Pick's disease results from a slowly progressive deterioration of social skills and changes in personality with the resulting symptoms being impairment of intellect, memory, and language. Common symptoms include memory loss, lack of spontaneity, difficulty in thinking or concentrating, and speech disturbances. Currently, there is no specific treatment or cure for Pick's disease but some symptoms can be treated with cholinergic and serotonin-boosting antidepressants. In addition, antipsychotic medications may alleviate symptoms in FTD patients who are experiencing delusions or hallucinations. Therefore, there is a need for a pharmaceutical agent to treat the progressive deterioration of social skills and changes in personality and to address the symptoms with fewer side effects.

Dysregulation of food intake associated with eating disease, including bulimia nervosa and anorexia nervosa, involve neurophysiological pathways. Anorexia nervosa is hard to treat due to patients not entering or remaining in after entering programs. Currently, there is no effective treatment for persons suffering from severe anorexia nervosa. Cognitive behavioral therapy has helped patients suffering from bulimia nervosa; however, the response rate is only about 50% and current treatment does not adequately address emotional regulation. Therefore, there is a need for pharmaceutical agents to address neurophysiological problems underlying diseases of dysregulation of food intake.

Cigarette smoking has been recognized as a major public health problem for a long time. However, in spite of the public awareness of health hazard, the smoking habit remains extraordinarily persistent and difficult to break. There are many



treatment methods available, and yet people continue to smoke. Administration of nicotine transdermally, or in a chewing gum base is common treatments. However, nicotine has a large number of actions in the body, and thus can have many side effects. It is clear that there is both a need and a demand of long standing for a  
5 convenient and relatively easy method for aiding smokers in reducing or eliminating cigarette consumption. A drug that could selectively stimulate only certain of the nicotinic receptors would be useful in smoke cessation programs.

Smoke cessation programs may involve oral dosing of the drug of choice. The drug may be in the form of tablets. However, it is preferred to administer the daily  
10 dose over the waking hours, by administration of a series of incremental doses during the day. The preferred method of such administration is a slowly dissolving lozenge, troche, or chewing gum, in which the drug is dispersed. Another drug in treating nicotine addiction is Zyban. This is not a nicotine replacement, as are the gum and patch. Rather, this works on other areas of the brain, and its effectiveness is to help  
15 control nicotine craving or thoughts about cigarette use in people trying to quit. Zyban is not very effective and effective drugs are needed to assist smokers in their desire to stop smoking. These drugs may be administered transdermally through the use of skin patches. In certain cases, the drugs may be administered by subcutaneous injection, especially if sustained release formulations are used.

20 Drug use and dependence is a complex phenomenon, which cannot be encapsulated within a single definition. Different drugs have different effects, and therefore different types of dependence. Drug dependence has two basic causes, that is, tolerance and physical dependence. Tolerance exists when the user must take progressively larger doses to produce the effect originally achieved with smaller  
25 doses. Physical dependence exists when the user has developed a state of physiologic adaptation to a drug, and there is a withdrawal (abstinence) syndrome when the drug is no longer taken. A withdrawal syndrome can occur either when the drug is discontinued or when an antagonist displaces the drug from its binding site on cell receptors, thereby counteracting its effect. Drug dependence does not always require  
30 physical dependence.

In addition drug dependence often involves psychological dependence, that is, a feeling of pleasure or satisfaction when taking the drug. These feelings lead the user to repeat the drug experience or to avoid the displeasure of being deprived of the drug.

Drugs that produce strong physical dependence, such as nicotine, heroin and alcohol are often abused, and the pattern of dependence is difficult to break. Drugs that produce dependence act on the CNS and generally reduce anxiety and tension; produce elation, euphoria, or other pleasurable mood changes; provide the user  
5 feelings of increased mental and physical ability; or alter sensory perception in some pleasurable manner. Among the drugs that are commonly abused are ethyl alcohol, opioids, anxiolytics, hypnotics, cannabis (marijuana), cocaine, amphetamines, and hallucinogens. The current treatment for drug-addicted people often involves a combination of behavioral therapies and medications. Medications, such as  
10 methadone or LAAM (levo-alpha-acetyl-methadol), are effective in suppressing the withdrawal symptoms and drug craving associated with narcotic addiction, thus reducing illicit drug use and improving the chances of the individual remaining in treatment. The primary medically assisted withdrawal method for narcotic addiction is to switch the patient to a comparable drug that produces milder withdrawal  
15 symptoms, and then gradually taper off the substitute medication. The medication used most often is methadone, taken orally once a day. Patients are started on the lowest dose that prevents the more severe signs of withdrawal and then the dose is gradually reduced. Substitutes can be used also for withdrawal from sedatives. Patients can be switched to long-acting sedatives, such as diazepam or phenobarbital,  
20 which are then gradually reduced.

Gilles de la Tourette's Syndrome is an inherited neurological disorder. The disorder is characterized by uncontrollable vocal sounds called tics and involuntary movements. The symptoms generally manifest in an individual before the person is 18 years of age. The movement disorder may begin with simple tics that progress to  
25 multiple complex tics, including respiratory and vocal ones. Vocal tics may begin as grunting or barking noises and evolve into compulsive utterances. Coprolalia (involuntary scatologic utterances) occurs in 50% of patients. Severe tics and coprolalia may be physically and socially disabling. Tics tend to be more complex than myoclonus, but less flowing than choreic movements, from which they must be  
30 differentiated. The patient may voluntarily suppress them for seconds or minutes.

Currently simple tics are often treated with benzodiazepines. For simple and complex tics, Clonidine may be used. Long-term use of Clonidine does not cause tardive dyskinesia; its limiting adverse effect is hypotension. In more severe cases,

antipsychotics, such as Haloperidol may be required, but side effects of dysphoria, parkinsonism, akathisia, and tardive dyskinesia may limit use of such antipsychotics. There is a need for safe and effective methods for treating this syndrome.

Age-related macular degeneration (AMD) is a common eye disease of the macula which is a tiny area in the retina that helps produce sharp, central vision required for "straight ahead" activities that include reading and driving. Persons with AMD lose their clear, central vision. AMD takes two forms: wet and dry. In dry AMD, there is a slow breakdown of light-sensing cells in the macula. There currently is no cure for dry AMD. In wet AMD, new, fragile blood vessels growing beneath the macula as dry AMD worsens and these vessels often leak blood and fluid to cause rapid damage to the macula quickly leading to the loss of central vision. Laser surgery can treat some cases of wet AMD. Therefore, there is a need of a pharmaceutical agent to address AMD.

Glaucoma is within a group of diseases occurs from an increase in intraocular pressure causing pathological changes in the optical disk and negatively affects the field of vision. Medicaments to treat glaucoma either decrease the amount of fluid entering the eye or increase drainage of fluids from the eye in order to decrease intraocular pressure. However, current drugs have drawbacks such as not working over time or causing side effects so the eye-care professional has to either prescribe other drugs or modify the prescription of the drug being used. There is a need for safe and effective methods for treating problems manifesting into glaucoma.

Ischemic periods in glaucoma cause release of excitotoxic amino acids and stimulate inducible form of nitric oxide synthase (iNOS) leading to neurodegeneration. Alpha 7 nicotinic agonists may stimulate the release of inhibitory amino acids such as GABA which will dampen hyperexcitability. Alpha 7 nicotinic agonists are also directly neuroprotective on neuronal cell bodies. Thus alpha 7 nicotinic agonists have the potential to be neuroprotective in glaucoma.

Persons afflicted with pain often have what is referred to as the "terrible triad" of suffering from the pain, resulting in sleeplessness and sadness, all of which are hard on the afflicted individual and that individual's family. Pain can manifest itself in various forms, including, but not limited to, headaches of all severity, back pain, neurogenic, and pain from other ailments such as arthritis and cancer from its existence or from therapy to eradicate it. Pain can be either chronic (persistent pain

for months or years) or acute (short-lived, immediate pain to inform the person of possible injury and need of treatment). Persons suffering from pain respond differently to individual therapies with varying degrees of success. There is a need for safe and effective methods for treating pain.

5           Finally, the compounds of the present invention may be used in combination therapy with typical and atypical anti-psychotic drugs (also called an anti-psychotic agent). All compounds within the present invention are useful for and may also be used in combination with each other to prepare pharmaceutical compositions. Such combination therapy lowers the effective dose of the anti-psychotic drug and thereby  
10       reduces the side effects of the anti-psychotic drugs. Some typical anti-psychotic drugs that may be used in the practice of the invention include Haldol. Some atypical anti-psychotic drugs include Ziprasidone, Olanzapine, Risperidone, and Quetiapine.

          Compounds of Formula I can be prepared as shown in Scheme 1. The key step  
15       in the preparation of this class of compounds is the coupling of an amino-azabicyclic moiety with the requisite acid chloride (Lv = Cl), mixed anhydride (e.g., Lv = diphenyl phosphoryl, bis(2-oxo-3-oxazolidinyl)phosphinyl, or acyloxy of the general formula of O-C(O)-R<sub>Lv</sub>, where R<sub>Lv</sub> includes phenyl or *t*-butyl), or carboxylic acid (Lv = OH) in the presence of an activating agent. Suitable activating reagents are well  
20       known in the art, for examples see Kiso, Y., Yajima, H. "Peptides" pp. 39-91, San Diego, CA, Academic Press, (1995), and include, but are not limited to, agents such as carbodiimides, phosphonium and uronium salts (such as HATU).

#### Scheme 1

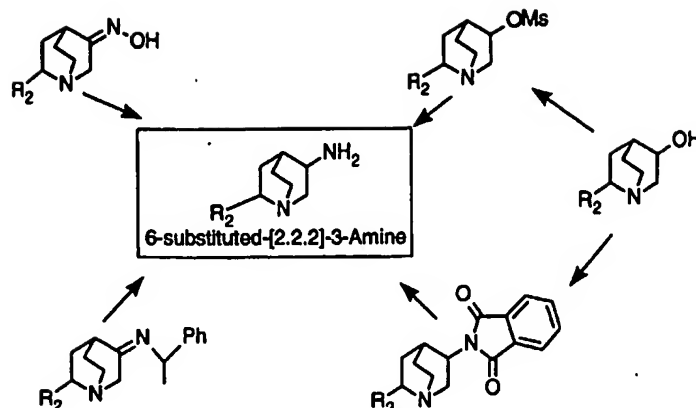


          Generally, the acid is activated using HATU or is converted to the acyl azide by using DPPA or is converted into a mixed anhydride by treatment with bis (2-oxo-3-oxazolidinyl) phosphinic chloride in the presence of TEA with CH<sub>2</sub>Cl<sub>2</sub> or CHCl<sub>3</sub> as the solvent; the resulting anhydride solution is directly reacted with the appropriate  
30       Azabicyclo moiety added neat or using DMF or aqueous DMF as solvent. In some cases, the ester (Lv being OMe or OEt) may be reacted directly with the amine in refluxing methanol or ethanol to give the compounds of Formula I.

The appropriate amine is treated with TEA if the amine is in the form of an acid salt and added to a solution of the appropriate anhydride or azide to give the desired final compounds. In some cases, the ester (Lv being OMe or OEt) may be reacted directly with the amine in refluxing methanol or ethanol to give the compounds of Formula I.

One of ordinary skill in the art will recognize that the methods described for the reaction of the unsubstituted 3-aminoquinuclidine ( $R_2$  is H) are equally applicable to substituted compounds ( $R_2$  is other than H). Certain 6-substituted-[2.2.2]-3-amines (Azabicyclo I) are known in the art. The preparation of compounds where  $R_2$  is at C-6 of the quinuclidine and is other than H is described in *Acta Pol. Pharm.* **1981**, 179. Certain 2-substituted-[2.2.2]-3-amines (Azabicyclo I) are known in the art. The preparation of compounds where  $R_2$  is at C-2 of the quinuclidine and is other than H is described in *J. Med. Chem.* **1975**, 18, 587.

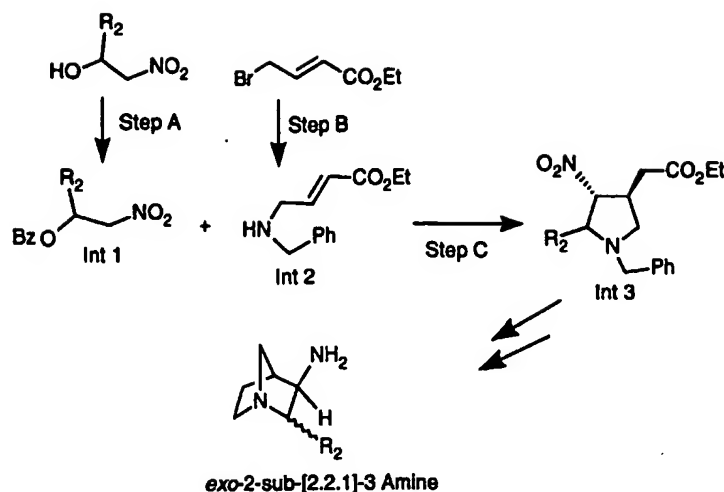
Alternatively, there are several methods to obtain the amine precursor for Azabicyclo I where  $R_2$  is other than H. Although the scheme depicted below is for compounds where  $R_2$  is at the C-6 position of the quinuclidine, one of ordinary skill in the art would be able to obtain the quinuclidine with substitution at C-2 also. The substituted-[2.2.2]-3-amine can be prepared by reduction of an oxime or an imine of the corresponding substituted-3-quinuclidinone by methods known to one of ordinary skill in the art (see *J. Labelled Compds. Radiopharm.* **1995**, 53; *J. Med. Chem.* **1998**, 988; *Synth. Commun.* **1992**, 1895; *Synth. Commun.* **1996**, 2009). Alternatively, the substituted-[2.2.2]-3-amine can be prepared from a substituted-3-hydroxyquinuclidine by Mitsunobu reaction followed by deprotection as described in *Synth. Commun.* **1995**, 1895. Alternatively, the substituted-[2.2.2]-3-amine can be prepared by conversion of a substituted-3-hydroxyquinuclidine into the corresponding mesylate or tosylate, followed by displacement with sodium azide and reduction as described in *J. Med. Chem.* **1975**, 587.



The 2-substituted-3-quinuclidinones, where R<sub>2</sub> is substituted alkyl or cycloalkyl, can be prepared by known procedures (see *Tet. Lett.* 1972, 1015; *J. Am. Chem. Soc.* 1994, 1278; *J. Am. Chem. Soc.* 1989, 4548; *Tetrahedron*, 2000, 1139).

- 5 The 2-substituted-3-quinuclidinones, where R<sub>2</sub> is aryl, can be prepared by palladium catalyzed arylation as described in *J. Am. Chem. Soc.* 1999, 1473 and *J. Am. Chem. Soc.* 2000, 1360. The 6-substituted-3-quinuclidinones can be prepared by known procedures (see *J. Gen. Chem. Russia* 1963, 3791, *J. Chem. Soc. Perkin Trans. I* 1991, 409, *J. Org. Chem.* 2000, 3982).

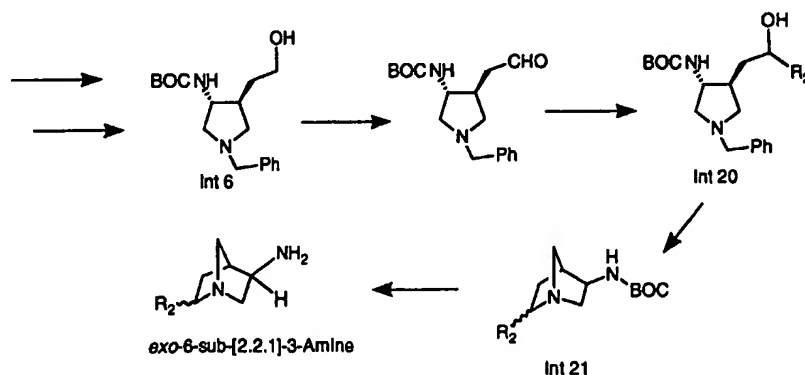
- 10 One of ordinary skill in the art will recognize that the methods described for the reaction of the unsubstituted 3-amino-1-azabicyclo[2.2.1]heptane (R<sub>2</sub>=H) are equally applicable to substituted compounds (R<sub>2</sub> ≠ H). For where Azabicyclo II has substitution at C-2, compounds can be prepared from appropriately substituted nitro alcohols using procedures described in *Tetrahedron* 1997, 53, p. 11121 as shown
- 15 below. Methods to synthesize nitro alcohols are well known in the art (see *J. Am. Chem. Soc.* 1947, 69, p 2608). The scheme below is a modification of the synthesis of *exo*-3-amino-1-azabicyclo[2.2.1]heptane as the bis(hydro para-toluenesulfonate) salt, described in detail herein, to show how to obtain these amine precursors. The desired salt can be made using standard procedures.



For Azabicyclo II where  $R_2$  is other than H at the C-6 position, compounds can also be prepared by modification of intermediates described in the synthesis of *exo*-3-amino-1-azabicyclo[2.2.1]heptane as the bis(hydro para-toluenesulfonate) salt, described in detail herein. For example, Int 6 can be oxidized to the aldehyde and

5 treated with an organometallic reagent to provide Int 20 using procedures described in *Tetrahedron* 1999, 55, p 13899. Int 20 can be converted into the amine using methods described for the synthesis of *exo*-3-amino-1-azabicyclo[2.2.1]heptane as the bis(hydro para-toluenesulfonate) salt. Once the amine is obtained, the desired salt can

10 be made using standard procedures.



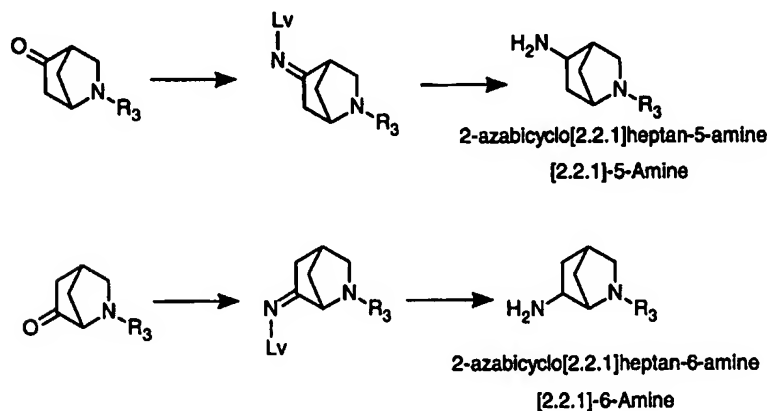
The schemes used are for making *exo*-3-amino-1-azabicyclo[2.2.1]heptane. However, the modifications discussed are applicable to make the *endo* isomer also.

One of ordinary skill in the art will also recognize that the methods described

15 for the reaction of the unsubstituted 1-azabicyclo[3.2.1]octan-3-amine or 1-azabicyclo[3.2.2]nonan-3-amine ( $R_2=H$ ) are equally applicable to substituted

compounds ( $R_2 \neq H$ ). The  $R_2$  substituent may be introduced as known to one skilled in the art through standard alkylation chemistry. Exposure of 1-azabicyclo[3.2.1]octan-3-one or 1-azabicyclo[3.2.2]nonan-3-one to a hindered base such as LDA (lithium diisopropylamide) in a solvent such as THF or ether between 0°C to -78°C followed by the addition of an alkylating agent ( $R_2Lv$ , where  $Lv = Cl, Br, I, OTs$ , etc.) will, after being allowed to warm to about 0°C to rt followed by an aqueous workup, provide the desired compound as a mixture of isomers. Chromatographic resolution (flash, HPLC, or chiral HPLC) will provided the desired purified alkylated ketones. From there, formation of the oxime and subsequent reduction will provide the desired stereoisomers.

***N*-(2-azabicyclo[2.2.1]hept)-5-amine and 6-amine:**



where Lv can be  $-\text{CH}_2\text{Ph}$ ,  $-\text{CH}(\text{Me})\text{Ph}$ ,  $-\text{OH}$ ,  $-\text{OMe}$ , or  $-\text{OCH}_2\text{Ph}$ .

15 The respective amine precursors for Azabicyclo V and Azabicyclo VI can be prepared by reduction of an oxime or an imine of the corresponding *N*-2-azabicyclo[2.2.1]-heptanone by methods known to one skilled in the art (see *J. Labelled Compds. Radiopharm.*, 53-60 (1995), *J. Med. Chem.* 988-995, (1998), *Synth. Commun.* 1895-1911 (1992), *Synth. Commun.* 2009-2015 (1996)). The oximes can be  
20 prepared by treatment of the *N*-2-azabicyclo[2.2.1]heptanones with hydroxylamine hydrochloride in the presence of a base. The imines can be prepared by treatment of the *N*-2-azabicyclo[2.2.1]-heptanones with a primary amine under dehydrating conditions. The *N*-2-azabicyclo[2.2.1]heptanones can be prepared by known



procedures (see *Tett. Lett.* 1419-1422 (1999), *J. Med. Chem.* 2184-2191 (1992), *J. Med. Chem.* 706-720 (2000), *J. Org. Chem.*, 4602-4616 (1995)).

It will be apparent to those skilled in the art that the requisite carboxylic acids can be obtained through synthesis via literature procedures or through the slight  
5 modification thereof.

## AMINES

### Preparation of *N*-(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]octan-3-amine 10 dihydrochloride (2*S*-methyl-2.2.2-Amine):

A mixture of 2-methylene-3-quinuclidinone dihydrate hydrochloride (27.18g, 0.1296mol, 1eq) and K<sub>2</sub>CO<sub>3</sub> (86.0g, 0.6213mol, 4.8eq) is dissolved in 130mL water and 250mL CH<sub>2</sub>Cl<sub>2</sub> and stirred vigorously. After 3 days, the layers are separated and the aqueous layer is extracted with CH<sub>2</sub>Cl<sub>2</sub>. The combined organic layers are dried  
15 (MgSO<sub>4</sub>), filtered and concentrated to give 17.8g (100%) of 2-methylenequinuclidin-3-one as a yellow oil. MS (ESI) for C<sub>8</sub>H<sub>11</sub>NO *m/z* 138.1 (M<sup>+</sup>).

2-Methylenequinuclidin-3-one (17.8g, 0.1296mol, 1eq) is dissolved in 40mL MeOH in a Parr hydrogenation bottle. A THF slurry of 10% Pd/C (0.57g) is added. The mixture is hydrogenated for 45 min at 45 psi, recharging as needed. The mixture  
20 is filtered through a pad of Celite. The Celite is washed with excess MeOH. The solution is concentrated to give a solid and a yellow oil. The mixture is taken up in ether, filtered and concentrated to provide 16.2g (90%) of 2-methylquinuclidin-3-one. MS (ESI) for C<sub>8</sub>H<sub>13</sub>NO *m/z* 140.2 (M<sup>+</sup>).

2-Methylquinuclidin-3-one (39.59g, 0.2844mol, 1eq) and hydroxylamine  
25 hydrochloride (20.0g, 0.2878mol, 1.01eq) are dissolved in 170mL absolute EtOH. The mixture is heated under reflux until a clear solution develops (about 20 min), after which is immediately followed by formation of a white precipitate. The reaction is cooled and allowed to stand overnight. The mixture is cooled in an ice bath, the solids are filtered and dried (house vacuum) to provide 46.4g of (3*E/Z*)-2-methyl-1-azabicyclo[2.2.2]octan-3-one oxime hydrochloride. A second crop of 2.4g is also  
30 obtained. Overall yield is 48.8g (90%). The 2-methyl-1-azabicyclo[2.2.2]octan-3-one oxime hydrochloride is a 4:1 mixture of oxime isomers. MS (ESI) for C<sub>8</sub>H<sub>14</sub>N<sub>2</sub>O *m/z*

154.8 (M<sup>+</sup>). Partial <sup>1</sup>H NMR (400 MHz, DMSO) δ 4.39 (0.2H), 4.29 (0.8H), 1.57 (0.6H), 1.47 (2.4H).

A solution of sodium *n*-propoxide (prepared from 5.5g sodium (0.24mol) and 100mL *n*-propanol) is added dropwise to a suspension of (3*E/Z*)-2-methyl-1-azabicyclo[2.2.2]octan-3-one oxime hydrochloride (45.8g, 0.24mol, 1eq) in 150 mL *n*-propanol. After complete addition, 250mL of *n*-propanol is added, and the mixture is heated under reflux. Sodium (55.2g, 2.40mol, 10 eq) is added in portions to the refluxing mixture. The mixture is heated under reflux overnight. After about 14h, the mixture is cooled, water is added and the layers are separated. The *n*-propanol layer is washed with brine and dried (MgSO<sub>4</sub>). The combined aqueous layers are extracted with CHCl<sub>3</sub> and dried (MgSO<sub>4</sub>). The combined, dried organic layers are treated with about 70mL concentrated HCl. The solvent is removed *in vacuo*. Absolute EtOH is added, and the solvent is removed. The sequence is repeated 2-3 times with fresh EtOH until a white solid formed. Absolute EtOH is added, the solids are filtered and dried (vacuum oven, about 60°C) to provide 36.5g of *trans* 3-amino-2-methylquinuclidine dihydrochloride. MS (ESI) for C<sub>8</sub>H<sub>16</sub>N<sub>2</sub> m/z 141.3 (M<sup>+</sup>). Additional material is obtained from the mother liquor: 7.8g (2<sup>nd</sup> crop) and 1.5g (3<sup>rd</sup> crop); this material is a mixture of both *trans* and *cis* isomers.

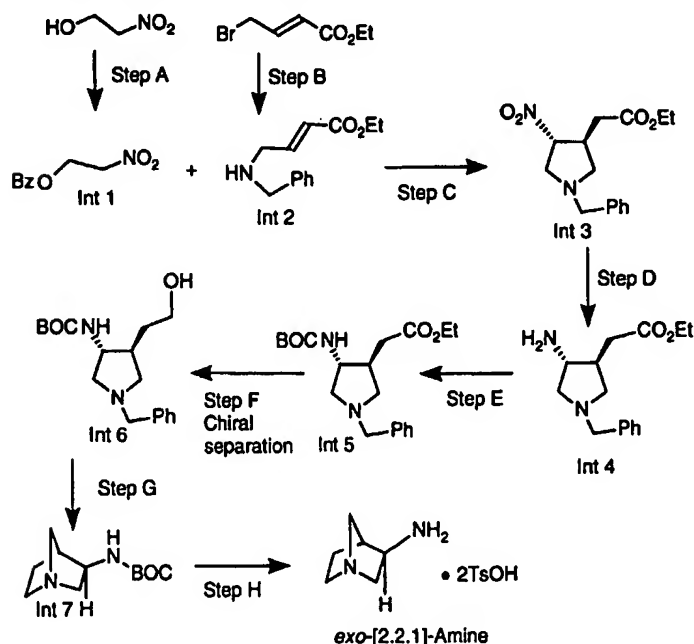
4-Chlorobenzoic acid (26.3g, 0.1681mol, 1.1eq) and TEA (106mL, 0.764mol, 5eq.) are dissolved in 300mL THF. Diphenylphosphoryl chloride (32.0mL, 0.1681mol, 1.1eq) is added dropwise. After 1h, *trans* 2-methylquinuclidin-3-amine dihydrochloride (32.6g, 0.1528mol, 1eq) is added. The mixture is allowed to stir at RT overnight. 1N NaOH (about 100mL) is added, and the pH is adjusted to pH 11 with 50% NaOH and about 50g K<sub>2</sub>CO<sub>3</sub>. The layers are separated. The aqueous layer is extracted with CHCl<sub>3</sub>. The combined organic layers are dried (MgSO<sub>4</sub>), filtered and concentrated. The residue is taken up in heptane and concentrated to give 35.1g (82%) of 4-chloro-*N*-(2-methyl-1-azabicyclo[2.2.2]oct-3-yl)phenyl-2-carboxamide as a light yellow solid. The enantiomers are separated on a 5 x 50 cm Chiralcel OD column at 30°C, eluting with 15% IPA/heptane + 0.1% DEA at 90mL/min to provide 17.4g of the eutomer at about 97% ee. The p-TsOH salt is prepared and recrystallized from EtOH/EtOAc. [α]<sub>D</sub><sup>25</sup> = +3° (c 0.96, methanol). HRMS (FAB) calcd for C<sub>15</sub>H<sub>19</sub>ClN<sub>2</sub>O +H 279.1264, found 279.1272..

A solution of 4-chloro-*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]benzamide (17.2g, 61.7mmol) in absolute EtOH (70mL) and concentrated HCl (70mL) is heated under reflux for about 64h. The reaction is monitored for disappearance of starting amide by reverse phase HPLC (ZORBAX Eclipse XDB-C8, 4.6mm x 15cm, 80:12:8 H<sub>2</sub>O/CH<sub>3</sub>CN/IPA). The solvent is removed *in vacuo*. The residue is dissolved/suspended in EtOH and the solvent is removed (twice). The solid is suspended in boiling EtOH, filtered and dried (vacuum oven, about 60°C) to provide 8.8g (67%) of *N*-(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]octan-3-amine dihydrochloride as a white solid. MS (EI) *m/z* 141.2 (*M*<sup>+</sup>).

10

### Preparation of the 1-azabicyclo-2.2.1 Amines:

Synthesis of (3*R*,4*S*)-3-amino-1-azabicyclo[2.2.1]heptane as the bis(hydro para-toluenesulfonate) salt (*exo*-[2.2.1]-Amine):



15 Step A. Preparation of 2-(benzoyloxy)-1-nitroethane (Int 1).

Benzoyl chloride (14.9 mL, 128 mmol) is added to a stirred solution of nitroethanol (9.2 mL, 128 mmol) in dry benzene (120 mL). The solution is refluxed for 24 hr and then concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with hexanes-EtOAc (80:20) affords Int 1 as a

20 white solid (68% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.0, 7.6, 7.4, 4.9, 4.8.

Step B. Preparation of ethyl *E*-4-(benzylamino)-2-butenate (Int 2).

Ethyl *E*-4-bromo-2-butenate (10 mL, 56 mmol, tech grade) is added to a stirred solution of benzylamine (16 mL, 146 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (200 mL) at rt. The reaction mixture stirs for 15 min, and is diluted with ether (1 L). The mixture is washed with saturated aqueous NaHCO<sub>3</sub> solution (3x) and water, dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo*. The residue is purified by flash chromatography on silica gel. Elution with hexanes-EtOAc (70:30) affords Int 2 as a clear oil (62% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.4-7.2, 7.0, 6.0, 4.2, 3.8, 3.4, 2.1-1.8, 1.3.

Step C. Preparation of *trans*-4-nitro-1-(phenylmethyl)-3-pyrrolidineacetic acid ethyl ester (Int 3).

A solution of Int 1 (6.81 g, 34.9 mmol) and Int 2 (7.65 g, 34.9 mmol) in EtOH (70 mL) stirs at rt for 15 h and is then concentrated *in vacuo*. The residue is diluted with ether (100 mL) and saturated aqueous NaHCO<sub>3</sub> solution (100 mL). The organic layer is separated and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with hexanes-EtOAc (85:15) affords Int 3 as a clear oil (76% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.4-7.3, 4.8-4.7, 4.1, 3.8-3.6, 3.3-3.0, 2.7-2.6, 2.4-2.3, 1.2.

Step D. Preparation of *trans*-4-amino-1-(phenylmethyl)-3-pyrrolidineacetic acid ethyl ester (Int 4).

A mixture of Int 3 (3.28 g, 11.2 mmol) and RaNi (1.5 g) in EtOH (100 mL) is placed in a Parr bottle and hydrogenated for 4 h under an atmosphere of hydrogen (46 psi) at rt. The mixture is filtered through a pad of Celite, and the solvent is removed *in vacuo* to afford Int 4 as a clear oil (100% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.3-7.2, 4.1, 3.6, 3.2, 3.0-2.9, 2.8, 2.8-2.6, 2.6-2.4, 2.30-2.2, 1.2.

Step E. Preparation of *trans*-4-(1,1-dimethylethoxycarbonylamido)-1-(phenylmethyl)-3-pyrrolidineacetic acid ethyl ester (Int 5).

Di-*tert*-butyldicarbonate (3.67 g, 16.8 mmol) is added to a stirred solution of Int 4 (2.94 g, 11.2 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (30 mL) cooled in an ice bath. The reaction is allowed to warm to rt and stirred overnight. The mixture is concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with

hexanes-EtOAc (80:20) affords Int 5 as a white solid (77% yield):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  7.4-7.2, 5.1-4.9, 4.1, 4.0-3.8, 3.6, 3.2-3.0, 2.8-2.6, 2.5-2.4, 2.3-2.1, 1.4, 1.3.

5    Step F.        Preparation of *trans* (*tert*-butoxycarbonylamino)-4-(2-hydroxyethyl)-1-(*N*-phenylmethyl) pyrrolidine (Int 6).

LiAlH<sub>4</sub> powder (627 mg, 16.5 mmol) is added in small portions to a stirred solution of Int 5 (3.0 g, 8.3 mmol) in anhydrous THF (125 mL) in a -5°C bath. The mixture is stirred for 20 min in a -5°C bath, then quenched by the sequential addition  
10    of water (0.6 mL), 15% (w/v) aqueous NaOH (0.6 mL) and water (1.8 mL). Excess anhydrous K<sub>2</sub>CO<sub>3</sub> is added, and the mixture is stirred for 1 h, then filtered. The filtrate is concentrated *in vacuo*. The residue is purified by flash chromatography on silica gel. Elution with EtOAc affords Int 6 as a white solid (94% yield):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  7.4-7.3, 5.3-5.2, 4.1-4.0, 3.9-3.7, 3.3-3.2, 2.8-2.7, 2.3-2.1, 1.7,  
15    1.5.

Int 6 is a racemic mixture that can be resolved via chromatography using a Diacel chiral pack AD column. From the two enantiomers thus obtained, the (+)-enantiomer,  $[\alpha]^{25}_{\text{D}} +35$  (c 1.0, MeOH), gives rise to the corresponding  
20    enantiomerically pure *exo*-4-*S* final compounds, whereas the (-)-enantiomer,  $[\alpha]^{25}_{\text{D}} -34$  (c 0.98, MeOH), gives rise to enantiomerically pure *exo*-4-*R* final compounds. The methods described herein use the (+)-enantiomer of Int 6 to obtain the enantiomerically pure *exo*-4-*S* final compounds. However, the methods used are equally applicable to the (-)-enantiomer of Int 6, making non-critical changes to the  
25    methods provided herein to obtain the enantiomerically pure *exo*-4-*R* final compounds.

Step G.        Preparation of *exo* 3-(*tert*-butoxycarbonylamino)-1-azabicyclo[2.2.1]heptane (Int 7).

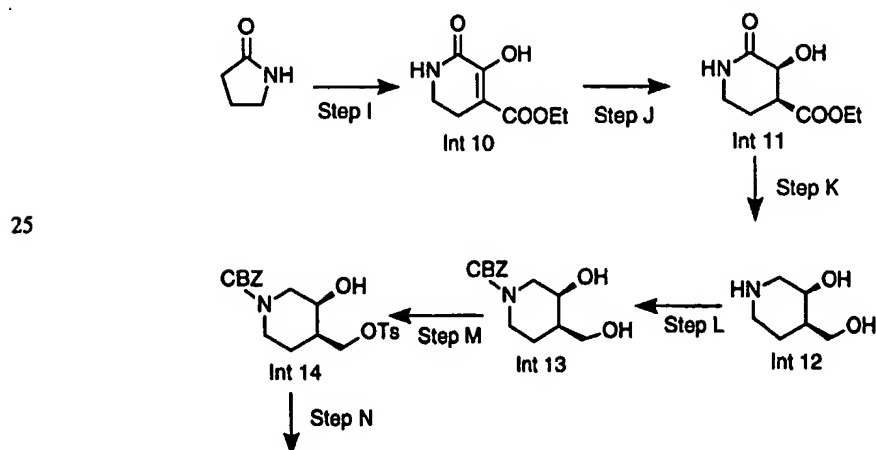
TEA (8.0 g, 78.9 mmol) is added to a stirred solution of Int 6 (2.5 g, 7.8 mmol)  
30    in CH<sub>2</sub>Cl<sub>2</sub> (50 mL), and the reaction is cooled in an ice-water bath. CH<sub>3</sub>SO<sub>2</sub>Cl (5.5 g, 47.8 mmol) is then added dropwise, and the mixture is stirred for 10 min in an ice-water bath. The resulting yellow mixture is diluted with saturated aqueous NaHCO<sub>3</sub>

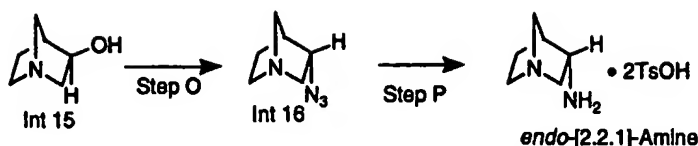
solution, extracted with CH<sub>2</sub>Cl<sub>2</sub> several times until no product remains in the aqueous layer by TLC. The organic layers are combined, washed with brine, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The residue is dissolved in EtOH (85 mL) and is heated to reflux for 16 h. The reaction mixture is allowed to cool to rt, transferred to a Parr bottle and treated with 10% Pd/C catalyst (1.25 g). The bottle is placed under an atmosphere of hydrogen (53 psi) for 16 h. The mixture is filtered through Celite, and fresh catalyst (10% Pd/C, 1.25 g) is added. Hydrogenolysis continues overnight. The process is repeated three more times until the hydrogenolysis is complete. The final mixture is filtered through Celite and concentrated *in vacuo*. The residue is purified by flash chromatography on silica gel. Elution with CHCl<sub>3</sub>-MeOH-NH<sub>4</sub>OH (90:9.5:0.5) affords Int 7 as a white solid (46% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 5.6-5.5, 3.8-3.7, 3.3-3.2, 2.8-2.7, 2.0-1.8, 1.7-1.5, 1.5.

**Step H.** Preparation of *exo*-3-amino-1-azabicyclo[2.2.1]heptane bis(hydro-*para*-toluenesulfonate).

*Para*-toluenesulfonic acid monohydrate (1.46 g, 7.68 mmol) is added to a stirred solution of Int 7 (770 mg, 3.63 mmol) in EtOH (50 mL). The reaction mixture is heated to reflux for 10 h, followed by cooling to rt. The precipitate is collected by vacuum filtration and washed with cold EtOH to give *exo*-[2.2.1]-Amine as a white solid (84% yield): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 7.7, 7.3, 3.9-3.7, 3.7-3.3, 3.2, 2.4, 2.3-2.2, 1.9-1.8.

Synthesis of *endo*-3-amino-1-azabicyclo[2.2.1]heptane as the bis(hydro *para*-toluenesulfonate) salt (*endo*-[2.2.1]-Amine):





Step I. Preparation of ethyl 5-hydroxy-6-oxo-1,2,3,6-tetrahydropyridine-4-carboxylate (Int 10).

Absolute EtOH (92.0 mL, 1.58 mol) is added to a mechanically stirred suspension of potassium ethoxide (33.2 g, 395 mmol) in dry toluene (0.470 L). When the mixture is homogeneous, 2-pyrrolidinone (33.6 g, 395 mmol) is added, and then a solution of diethyl oxalate (53.1 mL, 390 mmol) in toluene (98 mL) is added via an addition funnel. After complete addition, toluene (118 mL) and EtOH (78 mL) are added sequentially. The mixture is heated to reflux for 18 h. The mixture is cooled to rt and aqueous HCl (150 mL of a 6.0 M solution) is added. The mixture is mechanically stirred for 15 min. The aqueous layer is extracted with CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic layers are dried (MgSO<sub>4</sub>), filtered and concentrated *in vacuo* to a yellow residue. The residue is recrystallized from EtOAc to afford Int 10 as a yellow solid (38% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 11.4, 7.4, 4.3, 3.4, 2.6, 1.3.

15

Step J. Preparation of ethyl *cis*-3-hydroxy-2-oxopiperidine-4-carboxylate (Int 11).

A mixture of Int 10 (15 g, 81 mmol) and 5% rhodium on carbon (2.0 g) in glacial acetic acid is placed under an atmosphere of hydrogen (52 psi). The mixture is shaken for 72 h. The mixture is filtered through Celite, and the filtrate is concentrated *in vacuo* to afford Int 11 as a white solid (98% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 6.3, 4.2, 4.0-3.8, 3.4, 3.3-3.2, 2.2, 1.3.

20

Step K. Preparation of *cis*-4-(hydroxymethyl)piperidin-3-ol (Int 12).

Int 11 (3.7 g, 19.9 mmol) as a solid is added in small portions to a stirred solution of LiAlH<sub>4</sub> in THF (80 mL of a 1.0 M solution) in an ice-water bath. The mixture is warmed to rt, and then the reaction is heated to reflux for 48 h. The mixture is cooled in an ice-water bath before water (3.0 mL, 170 mmol) is added dropwise, followed by the sequential addition of NaOH (3.0 mL of a 15% (w/v) solution) and water (9.0 mL, 500 mmol). Excess K<sub>2</sub>CO<sub>3</sub> is added, and the mixture is stirred vigorously for 15 min. The mixture is filtered, and the filtrate is concentrated

30

*in vacuo* to afford Int 12 as a yellow powder (70% yield):  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ )  $\delta$  4.3, 4.1, 3.7, 3.5-3.2, 2.9-2.7, 2.5-2.3, 1.5, 1.3.

Step L. Preparation of benzyl *cis*-3-hydroxy-4-(hydroxymethyl)piperidine-1-carboxylate (Int 13).

*N*-(benzyloxy carbonyloxy)succinimide (3.04 g, 12.2 mmol) is added to a stirred solution of Int 12 (1.6 g, 12.2 mmol) in saturated aqueous  $\text{NaHCO}_3$  (15 mL) at rt. The mixture is stirred at rt for 18 h. The organic and aqueous layers are separated. The aqueous layer is extracted with ether (3X). The combined organic layers are dried over anhydrous  $\text{K}_2\text{CO}_3$ , filtered and concentrated *in vacuo* to afford Int 13 as a yellow oil (99% yield):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  7.4-7.3, 5.2, 4.3, 4.1, 3.8-3.7, 3.0-2.8, 2.1, 1.9-1.7, 1.4.

Step M. Preparation of benzyl *cis*-3-hydroxy-4-[(4-methylphenyl)sulfonyloxymethyl]piperidine-1-carboxylate (Int 14).

*Para*-toluenesulfonyl chloride (1.0 g, 5.3 mmol) is added to a stirred solution of Int 13 (3.6 g, 5.3 mmol) in pyridine (10 mL) in a  $-15^\circ\text{C}$  bath. The mixture is stirred for 4 h, followed by addition of HCl (4.5 mL of a 6.0 M solution).  $\text{CH}_2\text{Cl}_2$  (5 mL) is added. The organic and aqueous layers are separated. The aqueous layer is extracted with  $\text{CH}_2\text{Cl}_2$ . The combined organic layers are washed with brine, dried ( $\text{MgSO}_4$ ), filtered and concentrated *in vacuo* to afford Int 14 as a colorless oil (78% yield):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  7.8, 7.4-7.2, 5.1, 4.3-4.2, 4.1, 3.9-3.8, 2.9-2.7, 2.4, 1.9, 1.6-1.3.

Step N. Preparation of *exo*-1-azabicyclo[2.2.1]heptan-3-ol (Int 15).

A mixture of Int 14 (3.6 g, 8.6 mmol) and 10% Pd/C catalyst (500 mg) in EtOH (50 mL) is placed under an atmosphere of hydrogen. The mixture is shaken for 16 h. The mixture is filtered through Celite. Solid  $\text{NaHCO}_3$  (1.1 g, 13 mmol) is added to the filtrate, and the mixture is heated in an oil bath at  $50^\circ\text{C}$  for 5 h. The solvent is removed *in vacuo*. The residue is dissolved in saturated aqueous  $\text{K}_2\text{CO}_3$  solution. Continuous extraction of the aqueous layer using a liquid-liquid extraction apparatus (18 h), followed by drying the organic layer over anhydrous  $\text{K}_2\text{CO}_3$  and



removal of the solvent *in vacuo* affords Int 15 as a white solid (91% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 3.8, 3.0-2.8, 2.6-2.5, 2.4-2.3, 1.7, 1.1.

Step O. Preparation of *endo*-3-azido-1-azabicyclo[2.2.1]heptane (Int 16).

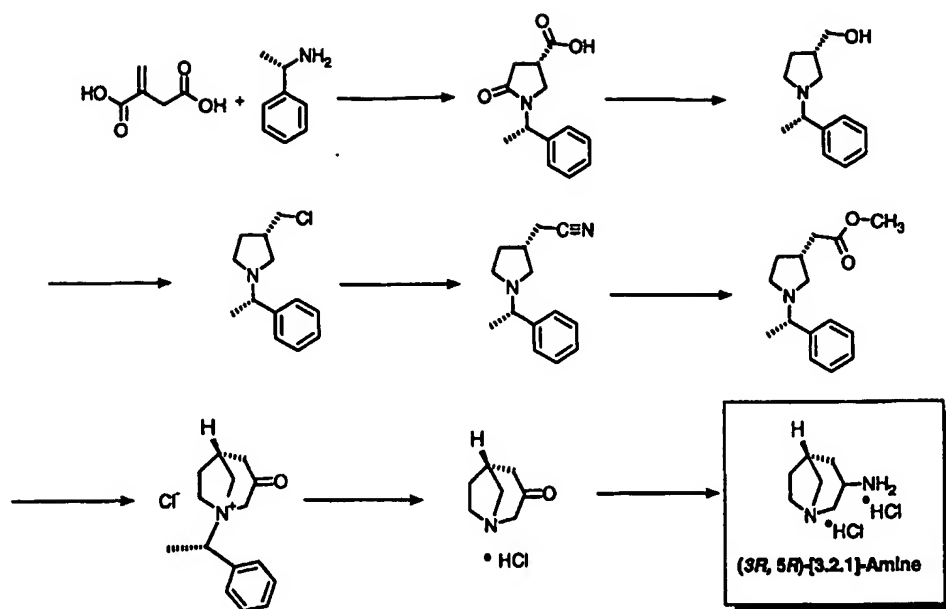
5 To a mixture of Int 15 (1.0 g, 8.9 mmol) and triphenyl phosphine (3.0 g, 11.5 mmol) in toluene-THF (50 mL, 3:2) in an ice-water bath are added sequentially a solution of hydrazoic acid in toluene (15 mL of ca. 2 M solution) and a solution of diethyl azadicarboxylate (1.8 mL, 11.5 mmol) in toluene (20 mL). The mixture is allowed to warm to rt and stir for 18 h. The mixture is extracted with aqueous 1.0M  
10 HCl solution. The aqueous layer is extracted with EtOAc, and the combined organic layers are discarded. The pH of the aqueous layer is adjusted to 9 with 50% aqueous NaOH solution. The aqueous layer is extracted with CH<sub>2</sub>Cl<sub>2</sub> (3X), and the combined organic layers are washed with brine, dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution  
15 with CHCl<sub>3</sub>-MeOH-NH<sub>4</sub>OH (92:7:1) affords Int 16 as a colorless oil (41% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 4.1, 3.2, 2.8, 2.7-2.5, 2.2, 1.9, 1.5.

Step P. Preparation of *endo*-3-amino-1-azabicyclo[2.2.1]heptane bis(hydro-*para*-toluenesulfonate).

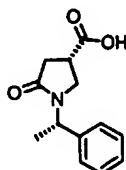
20 A mixture of Int 16 (250 mg, 1.8 mmol) and 10% Pd/C catalyst (12 mg) in EtOH (10 mL) is placed under an atmosphere of hydrogen (15 psi). The mixture is stirred for 1 h at rt. The mixture is filtered through Celite, and the filtrate is concentrated *in vacuo*. The residue is dissolved in EtOH (10 mL) and *para*-toluenesulfonic acid monohydrate (690 mg, 3.7 mmol) is added. The mixture is  
25 stirred for 30 min, and the precipitate is filtered. The precipitate is washed sequentially with cold EtOH and ether. The precipitate is dried *in vacuo* to afford *endo*-[2.2.1]-Amine as a white solid (85% yield): <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 7.7, 7.3, 4.2, 3.9, 3.6-3.4, 3.3-3.2, 2.4, 2.3, 2.1.

30 **Preparation of 1-azabicyclo[3.2.1]octan-3-amine:**

**Preparation of the 3*R*,5*R*-[3.2.1]-Amine:**



5

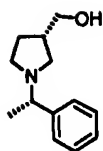
**(3S)-1-[(S)-1-Phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid:**

According to the literature procedure (Nielsen *et al.* J. Med. Chem 1990, 70-77), a mixture of itaconic acid (123.17 g, 946.7 mmol) and (S)-(-)- $\alpha$ -methyl benzylamine (122.0 mL, 946.4 mmol) were heated (neat) in a 160°C oil bath for 4 h. Upon cooling, MeOH (~200 mL) was added and the resulting solid collected by filtration. The solid was treated with EtOH (~700 mL) and warmed using a steam bath until ~450 mL solvent remained. After cooling to rt, the solid was collected and dried to afford 83.2 g as a white crystalline solid:  $[\alpha]^{25}_D = -80$  (c 0.97, DMSO). MS (EI)  $m/z$  233 ( $M^+$ ), 233, 218, 160, 105, 104, 103, 91, 79, 78, 77.

The lack of a resonance 3.59 indicates a single diastereomer. The other diastereomer can be retrieved from the initial MeOH tritulant. Attempts to crystallize this material generally led to small quantities of (3R,5R)-1-[(S)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid.

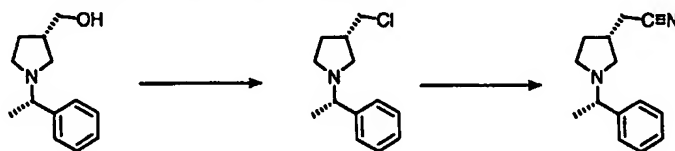
20

**(3S)-1-[(S)-1-Phenethyl]-3-(hydroxymethyl)pyrrolidine:**



A suspension (3*S*)-1-[(*S*)-1-phenethyl]-5-oxo-3-pyrrolidine-carboxylic acid (82.30 g, 352.8 mmol) in Et<sub>2</sub>O (200 mL) was added in small portions to a slurry of LiAlH<sub>4</sub> (17.41 g, 458.6 mmol) in Et<sub>2</sub>O (700 mL). The mixture began to reflux during the addition. The addition funnel containing the suspension was rinsed with Et<sub>2</sub>O (2 x 50 mL), and the mixture was heated in a 50 °C oil bath for an additional 2 h and first allowed to cool to rt and then further cooled using an ice bath. The mixture was carefully treated with H<sub>2</sub>O (62 mL). The resulting precipitate was filtered, rinsed with Et<sub>2</sub>O, and discarded. The filtrate was concentrated to a yellow oil. When EtOAc was added to the oil, a solid began to form. Hexane was then added and removed by filtration and dried to afford 43.3 g as a white solid.  $[\alpha]_D^{25} = -71$  (*c* 0.94, CHCl<sub>3</sub>). MS (EI) *m/z* 205 (M<sup>+</sup>), 191, 190, 128, 105, 91, 86, 84, 79, 77, 51.

**(3*R*)-1-[(*S*)-1-Phenethyl]-3-(cyanomethyl)pyrrolidine:**

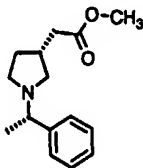


A solution of (3*S*)-1-[(*S*)-1-phenethyl]-3-(hydroxymethyl)pyrrolidine (42.75 g, 208.23 mmol) in chloroform (350 mL) was heated to reflux under N<sub>2</sub>. The solution was treated with a solution of thionyl chloride (41.8 mL, 573 mmol) in chloroform (40 mL) dropwise over 45 min. The mixture stirred for an additional 30 min, was cooled and concentrated. The residue was diluted with H<sub>2</sub>O (~200 mL), 1 N NaOH was added until a pH ~ 8 (pH paper). A small portion (~50 mL) of sat. NaHCO<sub>3</sub> was added and the basic mixture was extracted with EtOAc (3 x 400 mL), washed with brine, dried (MgSO<sub>4</sub>), filtered and concentrated to give 46.51 g of a red-orange oil for (3*S*)-1-[(*S*)-1-phenethyl]-3-(chloromethyl)pyrrolidine: *R<sub>f</sub>* 0.50 (EtOAc-hexane 1:1); MS (ESI<sup>+</sup>) *m/z* 224.2 (MH<sup>+</sup>). The chloride (46.35 g, 208.0 mmol) was transferred to a flask, dimethyl sulfoxide (200 mL) was added, and the solution was treated with NaCN (17.84 g, 363.9 mmol). The mixture was heated under N<sub>2</sub> in a 100°C oil bath overnight and was cooled. The brown mixture was poured into H<sub>2</sub>O (300 mL) and

extracted with EtOAc (1000 mL in portions). The combined organic layer was washed with H<sub>2</sub>O (6 x ~50 mL), brine (~100 mL), dried (MgSO<sub>4</sub>), filtered and concentrated to give 40.61 g as an orange-red oil: *R<sub>f</sub>*: 0.40 (EtOAc-PhCH<sub>3</sub> 1:1). MS (ESI+) for *m/z* 215.2 (M+H<sup>+</sup>).

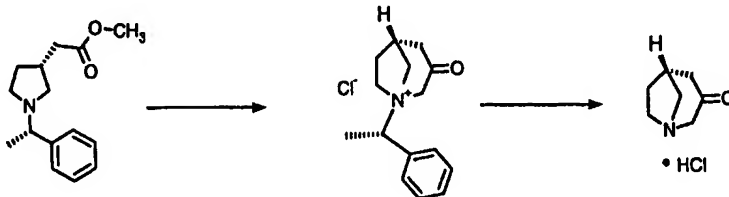
5

**(3*R*)-Methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate:**



Acetyl chloride (270 mL, 3.8 mol) was carefully added to a flask containing chilled (0°C) methanol (1100 mL). After the addition was complete, the acidic solution stirred for 45 min (0 °C) and then (3*R*)-1-[(*S*)-1-phenethyl]-3-  
 10 (cyanomethyl)pyrrolidine (40.50 g, 189.0 mmol) in methanol (200 mL) was added. The ice bath was removed and the mixture stirred for 100 h at rt. The resulting suspension was concentrated. Water (~600 mL) was added, the mixture stirred for 45 min and then the pH was adjusted (made basic) through the addition of ~700 mL sat.  
 15 aq. NaHCO<sub>3</sub>. The mixture was extracted with EtOAc (3 x 300 mL). The combined organics were washed with brine, dried (MgSO<sub>4</sub>), filtered through celite and concentrated to give 36.86 g as an orange-red oil. MS (ESI+) *m/z* 248.2 (M+H<sup>+</sup>).

**(5*R*)-1-Azabicyclo[3.2.1]octan-3-one hydrochloride:**

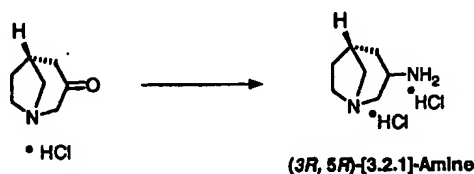


20

A solution of (3*R*)-methyl 1-[(*S*)-1-phenylethyl]pyrrolidine-3-acetate (25.72g, 104.0 mmol) in THF (265 mL) was cooled under N<sub>2</sub> in a CO<sub>2</sub>/acetone bath. Next, ICH<sub>2</sub>Cl (22.7 mL, 312.0 mmol) was added, and the mixture stirred for 30 min. A solution of 2.0M lithium diisopropylamide (heptane/THF/ethylbenzene, 156 mL, 312  
 25 mmol) was added slowly over 30 min. The internal temperature reached a maximum of -40°C during this addition. After 1 h, sat. NH<sub>4</sub>Cl (100 mL) was added and the mixture was allowed to warm to rt. The organic layer was separated, dried (MgSO<sub>4</sub>),

filtered and concentrated. The resulting red-brown foam was chromatographed (300 g SiO<sub>2</sub>, CHCl<sub>3</sub>-MeOH-NH<sub>4</sub>OH (89:10:1) followed by CHCl<sub>3</sub>-MeOH (3:1). The product fractions were pooled and concentrated to afford (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride (10.12 g) as a tan foam (MS (ESI+) *m/z* 230.1 (M+H<sup>+</sup>). This foam (10.1 g, 38 mmol) was taken up in MeOH (500 mL), 10% Pd(C) (3.0 g) added and the mixture was hydrogenated (45 psi) overnight. The mixture was filtered and re-subjected to the reduction conditions (9.1 g, 10% Pd/C, 50 psi). After 5 h, TLC indicated the consumption of the (5*R*)-3-oxo-1-[(1*S*)-1-phenylethyl]-1-azoniabicyclo[3.2.1]octane chloride. The mixture was filtered, concentrated and trituated (minimal *i*PrOH) to give 3.73 g of (5*R*)-1-azabicyclo[3.2.1]octan-3-one hydrochloride, in two crops, as an off-white solid:  $[\alpha]_D^{25} = 33$  (c 0.97, DMSO). MS (EI) *m/z* 125 (M<sup>+</sup>).

**(3*R*,5*R*)-1-azabicyclo[3.2.1]octan-3-amine dihydrochloride:**

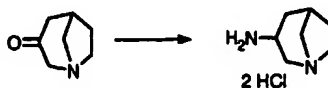


15

To a flask containing (5*R*)-1-azabicyclo[3.2.1]octan-3-one hydrochloride (3.64 g, 22.6 mmol), hydroxylamine hydrochloride (2.04 g, 29.4 mmol), and ethanol (130 mL) was added sodium acetate trihydrate (9.23 g, 67.8 mmol). The mixture stirred for 3 h and was filtered and concentrated. The resulting white solid was taken up in *n*-propanol (100 mL) and sodium (~13.6 g, 618 mmol) was added over 20-25 portions. The reaction spontaneously began to reflux, and the reaction was heated in an oil bath (100°C). The addition was complete in ~20 min and the mixture had solidified after ~40 min. The oil bath was removed and *n*-propanol (2 x 25 mL) was added dissolving the remaining sodium metal. The mixture was carefully quenched through the dropwise addition of H<sub>2</sub>O (100 mL). Saturated aq. NaCl (20 mL) was added, and the layers were separated. The organic layer was dried (MgSO<sub>4</sub>), filtered, treated with freshly prepared MeOH/HCl, and concentrated. The resulting solid was trituated with 30 mL EtOH, filtered and dried *in vacuo* to afford 3.51 g as a white solid:  $[\alpha]_D^{25} = -3$  (c 0.94, DMSO). MS (FAB) *m/z* 127 (MH<sup>+</sup>).

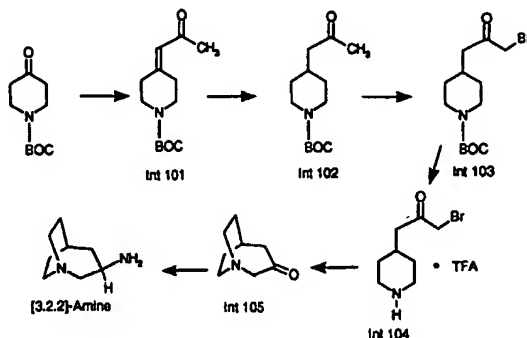
30

**Preparation of *endo*-1-azabicyclo[3.2.1]octan-3-amine dihydrochloride (*endo*-[3.2.1]-Amine):**



A mixture of 1-azabicyclo[3.2.1]octan-3-one hydrochloride (2.80 g, 17.3 mmol), ethanol (25 mL), and hydroxylamine hydrochloride (1.56 g, 22.4 mmol) is treated with sodium acetate trihydrate (7.07 g, 51.2 mmol). The mixture is stirred for 3 h and evaporated *in vacuo*. The residue is diluted with CH<sub>2</sub>Cl<sub>2</sub>, treated with charcoal, filtered and evaporated. The resulting oxime (3.1 mmol) is treated with acetic acid (30 mL) and hydrogenated at 50 psi over PtO<sub>2</sub> (50 mg) for 12 h. The mixture is then filtered and evaporated. The residue is taken up in a minimal amount of water (6 mL) and the pH is adjusted to >12 using solid NaOH. The mixture is then extracted with ethyl acetate (4 X 25 mL), dried (MgSO<sub>4</sub>), filtered, treated with ethereal HCl, and evaporated to give the *endo*-[3.2.1]-Amine.

**Preparation of the 3.2.2 Amines:**



**Preparation of *tert*-butyl 4-(2-oxopropylidene)piperidine-1-carboxylate (Int 101):**

Sodium hydride (60% oil dispersion, 2.01 g, 50.2 mmol) is washed with pentane (3X) and suspended in dry THF (40 mL). The solution is cooled to 0°C before diethyl (2-oxopropyl)phosphonate (9.75 g, 50.2 mmol) is added dropwise. After complete addition, the solution is warmed to rt and stirred for 30 min. *tert*-Butyl 4-oxo-1-piperidinecarboxylate (5.0g, 25.1 mmol) is added in portions over 10 min, followed by stirring at rt for 2 h. A saturated aqueous solution of ammonium chloride is added, followed by dilution with ether. The organic layer is extracted with water. The organic layer is dried over anhydrous MgSO<sub>4</sub>, filtered and concentrated to

a yellow oil. The crude product is purified by flash chromatography on silica gel. Elution with hexanes-ether (60:40) gave 4.5 g (75%) of Int 101 as a white solid: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 6.2, 3.5, 3.4, 2.9, 2.3, 2.2, 1.5.

5           Preparation of *tert*-butyl 4-(2-oxopropyl)piperidine-1-carboxylate (Int 102):

A mixture of Int 101 (4.5 g, 19 mmol) and 10% palladium on activated carbon (450mg) in EtOH (150 mL) is placed in a Parr bottle and hydrogenated for 5 h at 50 psi. The mixture is filtered through Celite, and the filtrate is concentrated *in vacuo* to afford 4.3 g (94%) of Int 102 as a clear oil: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 4.1, 2.8,  
10   2.4, 2.2, 2.0, 1.7, 1.5, 1.1.

Preparation of *tert*-butyl 4-(3-bromo-2-oxopropyl)piperidine-1-carboxylate (Int 103):

To a stirred solution lithium hexamethyldisilylamide in THF (20.0 mL, 1.0 M)  
15   in a -78 °C bath is added chlorotrimethylsilane (11.0 mL, 86.4 mmol) dropwise. The mixture is stirred at -78 °C for 20 min, followed by addition of Int 102 (3.21 g, 13.3 mmol) in a solution of THF (50 mL) dropwise. After complete addition, the mixture is stirred at -78 °C for 30 min. The mixture is warmed to 0°C in an ice-water bath and phenyltrimethylammonium tribromide (5.25 g, 14.0 mmol) is added. The mixture is  
20   stirred in an ice-bath for 30 min, followed by the addition of water and ether. The aqueous layer is washed with ether, and the combined organic layers are washed with saturated aqueous sodium thiosulfate solution. The organic layer is dried over anhydrous MgSO<sub>4</sub>, filtered and concentrated *in vacuo* to afford a yellow oil. The crude product is purified by flash chromatography on silica gel. Elution with hexanes-  
25   ether (60:40) gave 2.2 g (52%) of Int 103 as a lt. yellow oil: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 4.2-4.1, 3.9, 2.8, 2.7, 2.6, 2.1-2.0, 1.7, 1.5, 1.2-1.1.2.

Preparation of 1-bromo-3-piperidin-4-ylacetone trifluoroacetate (Int 104):

To a stirred solution of Int 103 (2.2 g, 6.9 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (30 mL) in an ice-  
30   water bath is added trifluoroacetic acid (10 mL, 130 mmol). The mixture is stirred at 0°C for 30 min. The volatiles are removed *in vacuo* to afford 2.0 g (87%) of Int 104 as a yellow residue: MS (ESI) for C<sub>8</sub>H<sub>15</sub>BrNO [M+H] *m/e* 220.

Preparation of 1-azabicyclo[3.2.2]nonan-3-one (Int 105):

To a stirred solution of DIEA (13 mL) in acetonitrile (680 mL) at reflux temperature is added a solution of Int 104 (2.0 g, 6.0 mmol) in acetonitrile (125 mL) over a 4 h period via syringe pump. The mixture is kept at reflux temperature overnight. The mixture is concentrated *in vacuo* and the remaining residue is partitioned between a saturated aqueous potassium carbonate solution and CHCl<sub>3</sub>-MeOH (90:10). The aqueous layer is extracted with CHCl<sub>3</sub>-MeOH (90:10), and the combined organic layers are dried (MgSO<sub>4</sub>), filtered and concentrated *in vacuo* to a brown oil. The crude product is purified by flash chromatography on silica gel. Elution with CHCl<sub>3</sub>-MeOH-NH<sub>4</sub>OH (95:4.5:0.5) gives 600 mg (72%) of Int 105 as a clear solid: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 3.7, 3.3-3.2, 3.1-3.0, 2.7, 2.3, 2.0-1.8.

Preparation of 1-azabicyclo[3.2.2]nonan-3-amine bis(4-methylbenzenesulfonate) ([3.2.2]-Amine):

To a stirred mixture of Int 105 (330 mg, 2.4 mmol) and sodium acetate•trihydrate (670 mg, 4.8 mmol) in EtOH (6.0 mL) is added hydroxylamine•hydrochloride (200 mg, 2.8 mmol). The mixture is stirred at rt for 10 h. The mixture is filtered and the filtrate is concentrated *in vacuo* to a yellow solid. To a solution of the solid (350 mg, 2.3 mmol) in *n*-propanol (30 mL) at reflux temperature is added sodium metal (2.0 g, 87 mmol) in small portions over 30 min. Heating at reflux is continued for 2 h. The solution is cooled to rt and brine is added. The mixture is extracted with *n*-propanol, and the combined organic layers are concentrated *in vacuo*. The residue is taken up in CHCl<sub>3</sub> and the remaining solids are filtered. The filtrate is dried over anhydrous MgSO<sub>4</sub>, filtered and concentrated *in vacuo* to a clear solid. To a stirred solution of the solid (320 mg, 2.3 mmol) in EtOH (4 mL) is added *p*-toluenesulfonic acid monohydrate (875 mg, 4.6 mmol). The solution is warmed in a water bath to 45°C for 30 min, followed by concentration of the solvent to afford 710 mg (62%) of [3.2.2]-Amine as a white solid: <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 7.7, 7.3, 4.1-3.9, 3.6-3.4, 2.6-2.5, 2.4, 2.2-2.1, 2.1-2.0, 1.9.

30

Resolution of stereoisomers:

The amine can be coupled to form the appropriate amides as a racemic mixture. The racemic mixture can then be resolved by chromatography using chiral



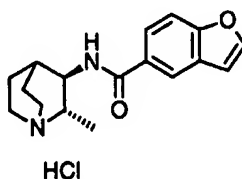
columns or chiral HPLC, techniques widely known in the art, to provide the requisite resolved enantiomers 3(R) and 3(S) of said amides.

### COUPLINGS

5        The following examples are provided as examples and are not intended to limit the scope of this invention to only those provided examples and named compounds. The named compounds provided herein can be made using procedures discussed herein, making non-critical changes and using procedures well known to those skilled in the art. Also, the salts made in the examples are only exemplary and  
10       are not intended to limit the invention. Any pharmaceutically acceptable salt can be made by one of ordinary skill in the art. Further, the naming of specific stereoisomers is for exemplification, and is not intended to limit in anyway the scope of the invention. The invention includes the following examples in pure stereoisomeric form or as racemic mixtures.

15

**Example 1:** *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide•hydrochloride:



1-(2,3-Dihydrobenzofuran-5-yl)ethanone is made using a procedure, making  
20       non-critical changes, as described in Dunn, J.P.; Ackerman, N.A.; Tomolois, A.J. *J. Med. Chem.* **1986**, 29, 2326. Similar yield (82%) and similar purity (95%) are obtained. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.89, 7.83, 6.84, 4.70, 3.29, 2.58.

A mixture of 1-(2,3-dihydrobenzofuran-5-yl)ethanone (4.0 g, 25 mmol) and sodium hypochlorite [160 mL of a 6.0% aqueous solution, (Clorox brand of bleach)]  
25       at 55°C is stirred for 1 h. The mixture (now homogeneous) is cooled to rt and solid sodium bisulfite is added until a clear color persists. Hydrochloric acid (80 mL of a 1.0 N aqueous solution) is added, followed by extraction with EtOAc. The organic layer is washed with brine, dried (MgSO<sub>4</sub>), filtered, and concentrated *in vacuo* to afford 3.93 g (97%) of 2,3-dihydrobenzofuran-5-carboxylic acid as a white solid. <sup>1</sup>H  
30       NMR (400 MHz, CDCl<sub>3</sub>) δ 11.0–10.3, 8.00, 6.87, 4.72, 3.31.

To a stirred solution of 2,3-dihydrobenzofuran-5-carboxylic acid (3.96 g, 24.1 mmol) in MeOH (200 mL) is added concentrated sulfuric acid (0.5 mL). The mixture is heated to reflux for 24 h. The mixture is cooled to rt, followed by the addition of solid sodium bicarbonate. The reaction mixture is concentrated *in vacuo*, and the  
5 remaining residue is partitioned between EtOAc and water. The aqueous layer is extracted with EtOAc, and the combined organic layers are dried (MgSO<sub>4</sub>), filtered and concentrated *in vacuo* to afford 4.22 g (98%) of methyl 2,3-dihydrobenzofuran-5-carboxylate as a white solid. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.93-7.89, 6.82, 4.69, 3.86, 3.28.

10 To a stirred solution of methyl 2,3-dihydrobenzofuran-5-carboxylate (4.2 g, 24 mmol) in anhydrous *p*-dioxane (150 mL) under argon atmosphere is added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (6.42 g, 28 mmol). The mixture is heated to reflux for 24 h, followed by cooling to rt. The reaction mixture is partitioned between ether and ½ saturated aqueous sodium carbonate solution. The organic layer is  
15 extracted several times with ½ saturated aqueous sodium carbonate solution. The organic layer is washed with water, dried over (MgSO<sub>4</sub>), filtered, and concentrated *in vacuo* to give a mixture (92%) of recovered starting material methyl 2,3-dihydrobenzofuran-5-carboxylate and methyl benzofuran-5-carboxylate in a ratio of 1:3. The crude product is purified by preparative HPLC using a Chiralcel OJ column.  
20 Elution with heptane-*iso*-propyl alcohol, (80:20, flow rate = 70 mL/min) gives 0.75 g (18%) of methyl 2,3-dihydrobenzofuran-5-carboxylate as a white solid and 2.5 g (61%) of methyl benzofuran-5-carboxylate as a white solid. <sup>1</sup>H NMR for methyl benzofuran-5-carboxylate (400 MHz, CDCl<sub>3</sub>) δ 8.40, 8.07, 7.73, 7.57, 6.89, 3.99.

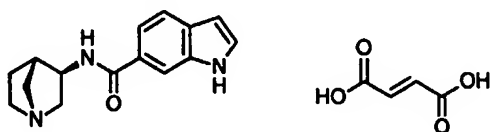
A stirred mixture of methyl benzofuran-5-carboxylate (1.3 g, 7.38 mmol) in  
25 MeOH (51 mL) and sodium hydroxide (41 mL of a 5 % aqueous solution) is heated to 65°C for 4 h. The mixture is cooled to rt, and MeOH is removed *in vacuo*. The remaining aqueous layer is extracted with CH<sub>2</sub>Cl<sub>2</sub>. The CH<sub>2</sub>Cl<sub>2</sub> layer is discarded, and the aqueous layer is acidified to pH=1 with concentrated hydrochloric acid. The aqueous layer is extracted with CHCl<sub>3</sub>. The organic layer is washed with water, dried  
30 (MgSO<sub>4</sub>), filtered and concentrated *in vacuo* to afford 1.2 g (98%) of benzofuran-5-carboxylic acid as a white solid. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) δ 12.9, 8.30, 8.11, 7.92, 7.69, 7.09.

Benzofuran-5-carboxylic acid (0.16g, 1.0mmol) and TEA (0.8mL, 5.7mmol) are dissolved in 10mL THF. Diphenylphosphinic chloride (0.24g, 1.0mmol) is added dropwise. After 0.5h, 2*S*-methyl-2.2.2-Amine is added, and the reaction is allowed to stir at RT. After 3 days, 1N NaOH is added, and the mixture is extracted with CHCl<sub>3</sub>.

- 5 The combined organic layers are dried (MgSO<sub>4</sub>), filtered and concentrated. The residue is purified by chromatography (Biotage 40S, 90:9:1 CHCl<sub>3</sub>/MeOH/NH<sub>4</sub>OH). The hydrochloride salt is prepared and recrystallized from MeOH/EtOAc to provide 0.036g (11%) of the product. HRMS (FAB) calcd for C<sub>17</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub>+H 285.1603, found 285.1599.

10

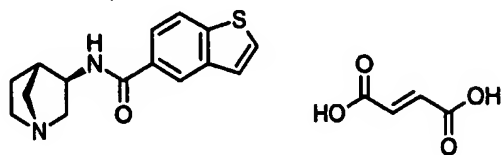
**Example 2:** *N*-[*exo*-(4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-6-carboxamide•fumarate:



- To a stirred solution of 1*H*-indole-6-carboxylic acid (81 mg, 0.5 mmol) in anhydrous DMF (10 mL) are added DIEA (265 μL, 1.52 mmol) and *exo*-(4*S*)-[2.2.1]-Amine (228 mg, 0.5 mmol). The mixture is cooled to 0°C, and HATU (190 mg, 0.5 mmol) is added in one portion. The reaction mixture is allowed to warm to rt and stir overnight. The solvent is removed *in vacuo*, and the residue is partitioned between saturated aqueous potassium carbonate solution and CHCl<sub>3</sub>. The aqueous layer is extracted with CHCl<sub>3</sub> (2x). The combined organic layers are washed with brine, dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with CHCl<sub>3</sub>-MeOH-NH<sub>4</sub>OH (89:9:1) gives the free base as a yellow solid (84 mg, 66%).

- To a stirred solution of the free base (84 mg, 0.33 mmol) in MeOH (5 mL) is added a warm solution of fumaric acid (38 mg, 0.33 mmol) in MeOH (5 mL). The mixture is stirred for 10 min at 50°C. The solvent is removed *in vacuo*, and the remaining residue is diluted with acetone (5 mL). The mixture is stirred overnight at rt. The solid is collected by filtration, washed with acetone, and dried under high vacuum overnight gives 88 mg (72%) of Example 2 as a white solid. <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 11.38, 8.32-8.31, 7.94, 7.58-7.50, 6.54, 6.48, 3.86-3.82, 3.15-3.10, 2.97-2.89, 2.67-2.55, 1.78-1.69, 1.38-1.31.

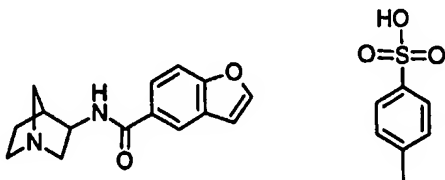
**Example 3:** *N*-[*exo*-(4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-5-carboxamide•fumarate:



5 To a stirred solution of 1-benzothiophene-5-carboxylic acid (see: Badger et. al., *J. Chem. Soc.* **1957**, 2624, 2628) (178 mg, 1.0 mmol) in anhydrous DMF (10 mL) are added DIEA (631  $\mu$ L, 3.05 mmol) and *exo*-(4*S*)-[2.2.1]-Amine (456 mg, 1.0 mmol). The mixture is cooled to 0°C, and HATU (380 mg, 1.0 mmol) is added in one portion. The reaction mixture is allowed to warm to rt and stirred overnight. The solvent is removed *in vacuo*, and the residue is partitioned between saturated aqueous potassium carbonate solution and  $\text{CHCl}_3$ . The aqueous layer was extracted with  $\text{CHCl}_3$  (2x). The combined organic layers are washed with brine, dried ( $\text{Na}_2\text{SO}_4$ ), filtered and concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with  $\text{CHCl}_3$ -MeOH- $\text{NH}_4\text{OH}$  (89:9:1) gives the free base as a light yellow oil (272 mg, 100%).

To a stirred solution of the free base (272 mg, 1.0 mmol) in MeOH (5 mL) is added a warm solution of fumaric acid (116 mg, 1.0 mmol) in MeOH (5 mL). The mixture is stirred for 5 min at 50°C. The solvent is removed *in vacuo*, and the remaining residue is diluted with acetone (10 mL) and water (0.2 mL). The mixture is stirred overnight at rt. The solid is collected by filtration, washed with acetone, and dried under high vacuum overnight to give 300 mg (74%) of Example 3 as a white solid:  $^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.38, 8.05-8.02, 7.85-7.83, 7.73-7.18, 7.51-7.50, 6.71, 4.29-4.26, 3.76-3.71, 3.49-3.38, 3.28-3.23, 3.09-3.08, 2.23-2.15, 1.89-1.82.

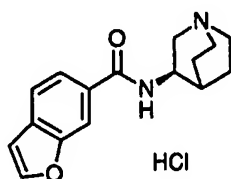
25 **Example 4:** *N*-[*exo*-(4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide•4-methylbenzenesulfonate:



To a stirred solution of 1-benzofuran-5-carboxylic acid (711 mg, 4.39 mmol) in anhydrous DMF (40 mL) are added DIEA (2.33 mL, 13.4 mmol) and *exo*-(4*S*)-[2.2.1]-Amine (2000 mg, 4.39 mmol). The mixture is cooled to 0°C, and HATU (1670 mg, 4.39 mmol) is added in one portion. The reaction mixture is allowed to warm to rt and is stirred overnight. The solvent is removed *in vacuo*, and the residue is partitioned between saturated aqueous potassium carbonate solution and CHCl<sub>3</sub>. The aqueous layer was extracted with CHCl<sub>3</sub> (2x). The combined organic layers were washed with brine, dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and concentrated in vacuo. The crude product was purified by flash chromatography on silica gel. Elution with CHCl<sub>3</sub>-MeOH-NH<sub>4</sub>OH (89:9:1) gives the free base as a white solid (1.09 g, 97.3%).

To a stirred solution of free base (1.09 g, 4.25 mmol) in MeOH (10 mL) is added a warm solution of *p*-toluenesulfonic acid monohydrate (809 mg, 4.25 mmol) in MeOH (10 mL). The mixture is stirred for 5 min at 42°C. The solvent is removed *in vacuo*, and the remaining residue is diluted with acetone (25 mL). The mixture is stirred overnight at rt. The solid is collected by filtration, washed with acetone, and dried under high vacuum overnight to give 1.62 g (89%) of Example 4 as a white solid: <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.19, 7.88-7.84, 7.73-7.70, 7.61-7.59, 7.25-7.23, 6.95, 4.30-4.27, 3.81-3.75, 3.55-3.42, 3.29, 3.11-3.10, 2.38, 2.26-2.17, 1.92-1.85.

**Example 5:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide hydrochloride:



3-Hydroxybenzoic acid (13.8 g, 100 mmol) is dissolved in concentrated NH<sub>4</sub>OH (200 mL) using an overhead stirrer and is treated slowly drop-wise with a solution of iodine (23.4 g, 92 mmol) and KI (18.26 g, 110 mmol) in water (100 mL). The solution is stirred for 1 h at RT and then treated rapidly drop-wise with concentrated HCl (180 mL). The solid is collected via filtration, rinsed with water and dried overnight by pulling air through the solid to afford 13.1 g (54%) of 3-

hydroxy-4-iodobenzoic acid as a tan solid.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ):  $\delta$  7.13, 7.43, 7.80, 10.71, 12.98 ppm.

3-Hydroxy-4-iodobenzoic acid (12.55 g, 47.5 mmol) is dissolved in MeOH (200 mL), treated slowly drop-wise with thionyl chloride (32.3 mL, 443 mmol) at RT, then heated to reflux for 20 h. The mixture is concentrated to dryness and partitioned between  $\text{CH}_2\text{Cl}_2$  (100 mL) and saturated  $\text{NaHCO}_3$  (50 mL). Not all of the residue dissolves, so the mixture is filtered and the solid is washed with a small amount of  $\text{CH}_2\text{Cl}_2$  in MeOH. The original filtrate and the organic washes are combined, concentrated to dryness, dissolved in 10% MeOH/ $\text{CH}_2\text{Cl}_2$  (200 mL), diluted with water (50 mL) and the layers separated. The organics are washed with saturated  $\text{NaHCO}_3$  (2 x 50 mL), then water (50 mL), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated to a tan solid. This solid is triturated with  $\text{CH}_2\text{Cl}_2$  (50 mL) and filtered. The two solids are combined to afford 9.4 g (70%) of methyl 3-hydroxy-4-iodobenzoate as a beige solid. HRMS (FAB) calcd for  $\text{C}_8\text{H}_7\text{IO}_3 + \text{H}$ : 278.9520, found 278.9521 ( $\text{M}+\text{H}$ ) $^+$ .

Methyl 3-hydroxy-4-iodobenzoate (5.22 g, 18.8 mmol) is combined with trimethylsilylacetylene (3.71 mL, 26.3 mmol), bis(triphenylphosphine)palladium dichloride (386 mg, 0.55 mmol) and cuprous iodide (54 mg, 0.28 mmol) in THF (20 mL) /  $\text{CHCl}_3$  (40 mL) in a dry flask, under nitrogen. Triethylamine (8.14 mL, 58.4 mmol) is added and the mixture is heated to 50°C for 4 h. The mixture is diluted with  $\text{CHCl}_3$  (60 mL), washed with 5% HCl (2 x 40 mL), dried ( $\text{MgSO}_4$ ) and concentrated to a brown oily-solid (8.31 g). The crude material is chromatographed over a standard 90 g Biotage column, eluting with 10% EtOAc/hexane (1 L) followed by 15 % EtOAc/hexane (1 L). The appropriate fractions are combined and concentrated to afford 4.22 g (91%) of methyl 3-hydroxy-4-[(trimethylsilyl)ethynyl]benzoate as a yellow solid. HRMS (FAB) calcd for  $\text{C}_{13}\text{H}_{16}\text{O}_3\text{Si} + \text{H}$ : 249.0947, found 249.0947 ( $\text{M}+\text{H}$ ) $^+$ .

Methyl 3-hydroxy-4-[(trimethylsilyl)ethynyl]benzoate (3.0 g, 12.1 mmol) is dissolved in 1:1 EtOH/ $\text{Et}_3\text{N}$  (30 mL), is treated with CuI (114 mg, 0.6 mmol), and the reaction is warmed to 75°C for 3 h. The mixture is treated with DARCO and MeOH (15 mL) and heated to reflux for 1 h. The reaction is filtered through a fine fritted-glass funnel, the filtrate is treated with 3N NaOH (24.2 mL, 72.5 mmol), and the mixture is stirred overnight at RT. The mixture is concentrated to dryness, the residue is dissolved in  $\text{H}_2\text{O}$  (20 mL), and the pH of the mixture is adjusted to 2 with 12N HCl.

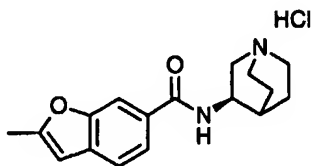
The resulting yellow precipitate is collected, washed with water, and is dried to give 1.83 g (93%) of benzofuran-6-carboxylic acid as a tan solid. HRMS (FAB) calcd for  $C_9H_6O_3 + H$ : 163.0395, found 163.0389 ( $M+H$ )<sup>+</sup>.

Method A:

- 5        1-Benzofuran-6-carboxylic acid (162 mg, 1.0 mmol) is combined with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol), DIEA (522  $\mu$ L, 3.0 mmol) and DMF (5 mL), cooled to 0°C, treated with HATU (380 mg, 1.0 mmol) and stirred for 18 h as the cooling bath expired. The mixture is concentrated under high vacuum and partitioned between a 1:1 solution of saturated NaCl/conc.  $NH_4OH$  (10 mL) and
- 10     $CHCl_3$  (3 x 10 mL). The organics are dried ( $Na_2SO_4$ ) and concentrated to an oil (530 mg). The crude material is chromatographed over 11 g slurry-packed silica gel, eluting with 2% conc.  $NH_4OH$ /10% MeOH/ $CHCl_3$ . The appropriate fractions are combined and concentrated to a dark yellow solid (274 mg). The solid is placed under high vacuum, dissolved in MeOH (5 mL), treated with 3N HCl MeOH (1 mL), stirred
- 15    for 16 h, then concentrated to dryness. The residue is dissolved in MeOH (1 mL) and IPA (10 mL) and treated with  $Et_2O$  (~20 mL) until turbid. The mixture is stirred for 16 h, filtered under nitrogen and dried in a vacuum oven at 50°C to afford 206 mg (67%) of Example 5 as an off-white solid. HRMS (FAB) calcd for  $C_{16}H_{18}N_2O_2 + H$ : 271.1446, found 271.1447 ( $M+H$ )<sup>+</sup>.

20

**Example 6:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide hydrochloride:



- 4-Hydroxybenzoic acid (34.5 g, 250 mmol) is suspended in MeOH (500 mL),
- 25    treated with NaI (34.5 g, 250 mmol) and NaOH (20 g, 500 mmol) and cooled to 0°C. Sodium hypochlorite (Clorox bleach) (423 mL, 250 mmol) is added slowly drop-wise at 0-5°C and the mixture is stirred for 1 h. The mixture is treated with saturated  $Na_2S_2O_3$  (135 mL) and water (135 mL) and stirred overnight as the cooling bath expired. The mixture is acidified to pH 3.5 with concentrated HCl and the resulting
- 30    precipitate filtered off. The solid contained a mixture of the desired mono-iodo

product and the iodo-chloro and the bis-iodo byproducts; it is discarded. The filtrate is concentrated to dryness, partitioned between H<sub>2</sub>O (300 mL) and EtOAc (1 x 500 mL, then 3 x 300 mL), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated to afford 59.6 g (90%) of 4-hydroxy-3-iodobenzoic acid as a white solid. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): δ 6.95, 7.80, 8.22 ppm.

4-Hydroxy-3-iodobenzoic acid (59.6 g, 226 mmol) is combined with 3N HCl/MeOH (276 mL, 678 mmol) and heated to 65°C for 24 h, then concentrated to dryness. The residue is diluted with water, neutralized to pH 7 with 3N NaOH and the resulting solid collected via filtration. The crude material is adsorbed onto silica gel and chromatographed over 1 kg of silica gel with 50% EtOAc/hexane. Fractions containing product are combined and concentrated to a solid (47.2 g). The material is recrystallized from EtOAc to afford 22.8 g (36%) of methyl 4-hydroxy-3-iodobenzoate as a white solid. HRMS (FAB) calcd for C<sub>8</sub>H<sub>7</sub>IO<sub>3</sub> +H: 278.9520, found 278.9534 (M+H)<sup>+</sup>.

Methyl 4-hydroxy-3-iodobenzoate (5.56 g, 20 mmol) is combined with trimethylsilylacetylene (3.96 mL, 28 mmol), bis(triphenylphosphine)palladium dichloride (414 mg, 0.6 mmol) and cuprous iodide (57 mg, 0.3 mmol) in THF (20 mL)/CHCl<sub>3</sub> (40 mL) in a dry flask, under nitrogen. TEA (8.7 mL, 62.3 mmol) is added and the mixture heated to 50°C for 4 h. The mixture is diluted with CHCl<sub>3</sub> (60 mL), washed with 5% HCl (2 x 40 mL), dried (MgSO<sub>4</sub>) and concentrated to a brown solid. The crude material is adsorbed onto silica gel and chromatographed over 200 g silica gel, eluting with 15% EtOAc/hexane (2 L) followed by 20% EtOAc/hexane (1 L). Fractions are combined and concentrated to afford 2.50 g (50%) of methyl 4-hydroxy-3-[(trimethylsilyl)ethynyl]benzoate as a yellow solid. HRMS (FAB) calcd for C<sub>13</sub>H<sub>16</sub>O<sub>3</sub>SI +H: 249.0947, found 249.0955 (M+H)<sup>+</sup>.

Methyl 4-hydroxy-3-[(trimethylsilyl)ethynyl]benzoate (11 g, 44.5 mmol) is combined with CuI (423 mg, 2.2 mmol) and DIA (7.1 mL, 50 mmol) in MeOH (110 mL) in a flask under nitrogen. The reaction is warmed to 60°C for 6 h, the volatiles are removed *in vacuo*, and the brown-green residue is chromatographed over 500 g silica gel (230–400 mesh) eluting with 20% EtOAc/hexane. Two pools are isolated to provide 3.43 g (31%) of the early eluting methyl 2-trimethylsilylbenzofuran-5-carboxylate and 2.63 g (33%) of the later eluting methyl benzofuran-5-carboxylate. The pools are combined in MeOH (130 mL). The solution is treated with 2N NaOH

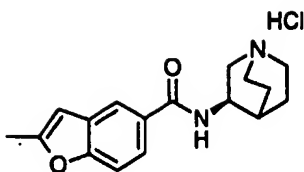


(46.8 ml, 93.6 mmol), is warmed to 50°C, and is stirred for 2 h. The mixture is cooled, the volatiles are removed *in vacuo*, and the residue is dissolved in water (50 mL). The pH of the mixture is adjusted to 2 with 12N HCl, is diluted with water (40 mL), and the mixture is cooled to 0°C. The off-white solid is collected, washed with water, and is dried to give 6.0 g. The solid is dried *in vacuo* over P<sub>2</sub>O<sub>5</sub> for 18 h to give 4.6 g (99%) of benzofuran-5-carboxylic acid as an off-white solid. MS for C<sub>9</sub>H<sub>6</sub>O<sub>3</sub>, (EI) *m/z*: 162 (M)<sup>+</sup>.

Methyl 3-hydroxy-4-iodobenzoate (2.0 g, 7.2 mmol) is dissolved in DMF (15 ml) in a dry flask under nitrogen with propargyl trimethylsilane (1.19 ml, 7.98 mmol), bis(triphenylphosphine)palladium dichloride (71 mg, 0.10 mmol), copper iodide (55 mg, 0.29 mmol), and piperidine (1.14 ml, 11.5 mmol). The reaction is heated at 45°C for 7 h and then stirred at RT overnight. The reaction mixture is diluted with EtOAc (75 ml) and washed with a 50% saturated solution of 1:1 NaCl/NaHCO<sub>3</sub> (4 x 25 ml). The organic layer is dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated to an amber oil. The crude material is chromatographed over 100 g slurry-packed silica gel, eluting with 20% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 1.5 g of a mixture methyl 2-methyl-benzofuran-5-carboxylate and the corresponding 2-TMS-methyl derivative, neither of which is isolated independently from one another. The mixture of esters is dissolved in MeOH (15 ml) and water (1 ml) and treated with 2N NaOH (3.15 ml, 6.3 mmol). After 2 days, the volatiles are removed *in vacuo* and the residue is dissolved in H<sub>2</sub>O (5 ml). TLC indicated the presence of 2 spots, so the solution is washed with Et<sub>2</sub>O (3 x 10 ml) to remove the undesired reaction component. The pH is then adjusted to 3 with concentrated HCl and the resulting slurry is filtered. The isolated cake is dried overnight to yield 789 mg (85%) of 2-methyl-1-benzofuran-6-carboxylic acid as a pale yellow solid. MS for C<sub>10</sub>H<sub>8</sub>O<sub>3</sub>, (EI) *m/z*: 176 (M)<sup>+</sup>.

2-Methyl-1-benzofuran-6-carboxylic acid (176 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) and the salt is made as described in Method A with non-critical changes to afford 282 mg (88%) of Example 6 as a white solid. HRMS (FAB) calcd for C<sub>17</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub>+H: 285.1603, found 285.1586 (M+H)<sup>+</sup>.

**Example 7:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide hydrochloride:

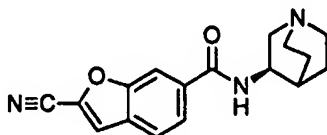


Methyl 4-hydroxy-3-iodobenzoate (3.0 g, 10.8 mmol) is dissolved in DMF (25 ml) in a dry flask under nitrogen with propargyl trimethylsilane (1.79 ml, 11.9 mmol), bis(triphenylphosphine)palladium dichloride (106 mg, 0.15 mmol), copper iodide (82 mg, 0.4 mmol), and piperidine (1.71 ml, 17.2 mmol). The reaction is heated at 45°C for 7 h and then at RT overnight. The reaction mixture is diluted with EtOAc (125 ml) and washed with 1:1 saturated NaCl/NaHCO<sub>3</sub> (4 x 50 ml). The organic is dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated to an oil. The crude material is chromatographed over 100 g slurry-packed silica gel, eluting with 15% EtOAc/hexane. The fractions containing the desired product are collected and concentrated to afford 2.4 g (85%) of intermediate methyl-2-trimethylsilylmethyl-benzofuran-5-carboxylate as an orange oil. The oil is dissolved in MeOH (25 ml) and H<sub>2</sub>O (3 ml) and treated with 2N NaOH (5.1 ml, 10.2 mmol). The reaction is monitored by TLC and required slight heating at 45°C for 6 h. An additional amount of 2N NaOH (5.0 ml, 10.0 mmol) is required to complete the hydrolysis. The volatiles are removed *in vacuo*, and the residue is dissolved in Et<sub>2</sub>O (15 ml). The pH is adjusted to 3 with 12N HCl and the resulting slurry is filtered. The isolated cake is dried overnight to yield 1.5 g (94%) of 2-methyl-1-benzofuran-5-carboxylic acid as a gray solid. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): δ 2.47, 6.70, 7.57, 7.85, 8.16, 12.81 ppm.

2-Methyl-1-benzofuran-5-carboxylic acid (176 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) and the salt is made according to Method A with non-critical changes to afford 273 mg (85%) of Example 7 as a white solid. HRMS (FAB) calcd for C<sub>17</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub>+H: 285.1603, found 285.1606 (M+H)<sup>+</sup>.

25

**Example 8:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide:



A dried flask under nitrogen is charged with methyl 3-hydroxy-4-iodobenzoate (10.0 g, 35.9 mmol), propionaldehyde diethyl acetal (5.72 ml, 40.0 mmol), bistriphenylphosphine palladium diacetate (538 mg, 0.72 mmol), copper iodide (273 mg, 1.4 mmol) and piperidine (3.94 ml, 40.0 mmol) in DMF (50 ml). The mixture is stirred at 45°C for 6 h, then at RT overnight. The reaction is diluted with EtOAc (250 ml) and washed with 50% saturated 1:1 NaCl/NaHCO<sub>3</sub> solution (4 x 100 ml). The organic layer is dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and concentrated to a brown oil. The crude material is chromatographed over 500 g slurry-packed silica, eluting with 15% EtOAc/hexane. The appropriate fractions are collected and concentrated, affording 3.22 g (32%) of methyl 2-(diethoxymethyl)-1-benzofuran-6-carboxylate as an orange oil. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 1.29, 3.72, 3.96, 5.70, 6.88, 7.61, 7.95, 8.20 ppm.

Methyl 2-(diethoxymethyl)-1-benzofuran-6-carboxylate (2.71 g, 9.7 mmol) is treated drop-wise with formic acid (20 ml, 530 mmol) and water (5.5 ml). The reaction is stirred overnight at RT, diluted with water (50 ml), and the brown slurry is filtered. The cake is dried overnight to afford 1.86 g (94%) of methyl 2-formyl-1-benzofuran-6-carboxylate as an amber solid. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): δ 3.91, 8.03, 8.28, 9.92 ppm.

Hydroxylamine hydrochloride (153 mg, 2.2 mmol) is free based for 5 min in 2N NaOH (1.1 ml, 2.2 mmol) and added drop-wise to a solution of methyl 2-formyl-1-benzofuran-6-carboxylate (408 mg, 2.0 mmol) in EtOH (6 ml). The reaction is stirred overnight and the volatiles are removed *in vacuo*. The residue is suspended in water (5 ml) and the slurry is filtered. The cake is dried overnight to afford 399 mg (91%) of *E/Z*-methyl 2-[(hydroxyimino)methyl]-1-benzofuran-6-carboxylate as a light brown solid. HRMS (FAB) calcd for C<sub>11</sub>H<sub>9</sub>NO<sub>4</sub>+H: 220.0610, found 220.0602 (M+H)<sup>+</sup>.

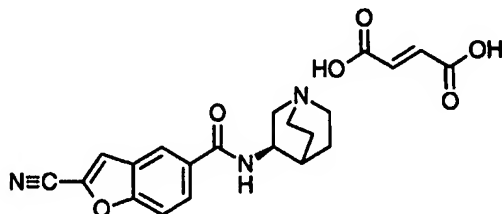
*E/Z*-Methyl 2-[(hydroxyimino)methyl]-1-benzofuran-6-carboxylate (438 mg, 2.0 mmol) is suspended in CH<sub>2</sub>Cl<sub>2</sub> (8 ml) in a dry flask under nitrogen. Pyridine (0.65 ml, 8.0 mmol) is added via syringe, and the mixture is cooled to 0°C. Trifluoroacetic anhydride (0.56 ml, 4.0 mmol) is added drop-wise, and the reaction is stirred overnight, allowing the ice bath to expire. The reaction is carefully quenched with saturated NaHCO<sub>3</sub> (10 ml). The layers are separated and the organic layer is dried (K<sub>2</sub>CO<sub>3</sub>), filtered, and concentrated to a pink solid. The crude material is chromatographed over 25 g slurry-packed silica gel, eluting with 25% EtOAc/hexane.

The appropriate fractions are collected and concentrated to afford 315 mg (78%) of methyl 2-cyano-1-benzofuran-6-carboxylate as a white solid.

Methyl 2-cyano-1-benzofuran-6-carboxylate (250 mg, 1.24 mmol) is suspended in pH = 7.0 buffer (20 ml). Pig liver esterase (41 units/mg) (150 mg, 6.21  
5 milli-equivalents) is dissolved in pH 7.0 buffer and added drop-wise to the suspension. The reaction is stirred vigorously overnight and is monitored by TLC. The mixture is filtered through celite, and the pH of the liquor is adjusted to 3 with concentrated HCl. The white, milky solution is filtered through a fine frit, and the resulting cake is dried overnight, yielding 246 mg (>100%, water present) of 2-cyano-  
10 1-benzofuran-6-carboxylic acid as a gray solid. MS (EI)  $m/z$ : 187 (M)<sup>+</sup>.

2-Cyano-1-benzofuran-6-carboxylic acid (226 mg, 1.2 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (265 mg, 1.33 mmol) and the salt is made according to Method A with non-critical changes to afford 268 mg (75%) of Example  
8 as a white solid. HRMS (FAB) calcd for C<sub>17</sub>H<sub>17</sub>N<sub>3</sub>O<sub>2</sub> +H: 296.1399, found  
15 296.1398 (M+H)<sup>+</sup>.

**Example 9:** *N*-[(3R)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide fumarate:



20 Methyl 4-hydroxy-3-iodo-benzoate (9.9 g, 35 mmol) is combined with propionaldehyde diethylacetal (5.6 ml, 39 mmol), bis(triphenylphosphine)palladium(II) chloride (523 mg, 0.7 mmol), cuprous iodide (266 mg, 1.4 mmol), and piperidine (3.9 ml, 39 mmol) in DMF (50 ml) in a dry flask under nitrogen. The reaction is warmed to 60°C for 6 h and is stirred overnight at RT. The mixture is diluted with EtOAc  
25 (250 ml) and is washed with 2:1:1:0.1 water/brine/saturated NaHCO<sub>3</sub>/conc. NH<sub>4</sub>OH (4 x 100 ml). The organic layer is dried (MgSO<sub>4</sub>) and is concentrated *in vacuo* to a dark oil. The crude material is chromatographed over 300 g silica gel (230-400 mesh), eluting with 15% EtOAc/hexane. The appropriate fractions are combined and concentrated to afford 5.2 g (48%) methyl 2-(diethoxymethyl)-1-benzofuran-5-

carboxylate as an amber oil. HRMS (EI) calcd for  $C_{15}H_{18}O_5$ : 278.1154, found 278.1156 (M)<sup>+</sup>.

Methyl 2-(diethoxymethyl)-1-benzofuran-5-carboxylate (2.6 g, 8.5 mmol) is combined with formic acid (15 ml) and water (3.8 ml). The reaction is stirred 6 h at  
5 RT, the volatiles are removed *in vacuo*, and the residue is neutralized with 50 ml saturated  $NaHCO_3$ . The mixture is extracted with  $CH_2Cl_2$  (4 x 20 ml), the organic layer is dried ( $K_2CO_3$ ), and is concentrated *in vacuo* to provide 1.72 g (99%) of methyl 2-formyl-1-benzofuran-5-carboxylate as amber flakes. HRMS (EI) calcd for  $C_{11}H_8O_4$ : 204.0423, found 204.0418 (M)<sup>+</sup>.

10 Methyl 2-formyl-1-benzofuran-5-carboxylate (1.64 g, 8.0 mmol) is dissolved in ethanol (30 ml). The solution is treated with hydroxylamine hydrochloride (614 mg, 8.8 mmol) in 2N NaOH (4.2 ml), and the reaction is stirred overnight at RT. The reaction mixture is concentrated to dryness, the residue is triturated with water, collected, and dried to give 1.7 g (97%) of methyl 2-[(E,Z)-(hydroxyimino)methyl]-1-  
15 benzofuran-5-carboxylate as a pale yellow solid. HRMS (EI) calcd for  $C_{11}H_9NO_4$ : 219.0531, found 219.0536 (M)<sup>+</sup>.

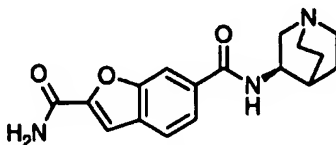
Methyl 2-[(E,Z)-(hydroxyimino)methyl]-1-benzofuran-5-carboxylate (1.65 g, 7.53 mmol) is dissolved in  $CH_2Cl_2$  (40 ml) in a dry flask under nitrogen. The solution is treated with pyridine (2.5 ml, 30.1 mmol) followed by trifluoroacetic anhydride  
20 (2.10 ml, 15.1 mmol), and the reaction is stirred 4 h at RT. The reaction mixture is washed with 5% aqueous HCl (100 ml) followed by saturated  $NaHCO_3$  (100 ml), the organic layer is dried ( $K_2CO_3$ ), and is concentrated *in vacuo* to a pale yellow solid. The crude material is chromatographed over 50 g silica gel (230-400 mesh) eluting with 10% EtOAc/hexane. The appropriate fractions are combined and concentrated *in*  
25 *vacuo* to give 700 mg (44%) of methyl 2-cyano-1-benzofuran-5-carboxylate as a white solid.  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  3.98, 7.55, 7.60, 8.23, 8.44 ppm.

Methyl 2-cyano-1-benzofuran-5-carboxylate (126 mg, 0.62 mmol) is suspended in pH 7.0 buffer (7 ml). Pig Liver Esterase (41 units/mg) (76 mg, 3.13 milli-equivalents) is dissolved in pH 7.0 buffer (3 ml) and added drop-wise to the  
30 suspension. The reaction is stirred vigorously overnight and monitored by TLC. The mixture is filtered through celite, and the pH of the liquor is adjusted to 3 with concentrated HCl. The white, milky solution is filtered through a fine frit, and the resulting cake is dried overnight, yielding 122 mg (>100%, water present) of 2-cyano-

1-benzofuran-5-carboxylic acid as a crunchy, tan solid.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ):  $\delta$  7.85, 8.16, 8.21, 8.45 ppm.

2-Cyano-1-benzofuran-5-carboxylic acid (129 mg, 0.7 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (151 mg, 0.75 mmol) according to Method A except that the free base is dissolved in methanol (1 ml) and EtOAc (8 ml). Fumaric acid (41 mg, 0.37 mmol) is added portionwise, and the mixture stirred overnight. The volatiles are removed *in vacuo*, to afford 123 mg (43%) of Example 9 as a white solid. MS (EI)  $m/z$ : 295 (M) $^+$ .

10 **Example 10:** *N*-6-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,6-dicarboxamide:



Methyl 2-formyl-1-benzofuran-6-carboxylate (1.23 g, 6.0 mmol) is dissolved in DMSO (12 ml).  $\text{KH}_2\text{PO}_4$  (229 mg, 1.68 mmol) in  $\text{H}_2\text{O}$  (2ml) and  $\text{NaClO}_2$  (80%, 949 mg, 8.4 mmol) in  $\text{H}_2\text{O}$  (12 ml) are added drop-wise to the solution, and the reaction is stirred over the weekend at RT. The pH is adjusted to 10 with 2N NaOH and the mixture is extracted with  $\text{Et}_2\text{O}$  (3 x 50 ml). The pH is adjusted again to 3 with concentrated HCl and the slurry is filtered. The cake is dried overnight, yielding 1.07 g (81%) of 6-(methoxycarbonyl)-1-benzofuran-2-carboxylic acid as an ivory solid. HRMS (FAB) calcd for  $\text{C}_{11}\text{H}_8\text{O}_5 + \text{H}$ : 221.0450, found 221.0436 (M+H) $^+$ .

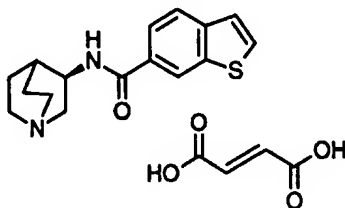
6-(Methoxycarbonyl)-1-benzofuran-2-carboxylic acid (220 mg, 1.0 mmol) is combined with HATU (570 mg, 1.5 mmol) in DMF (4 mL). The mixture is treated portionwise with DIEA (350  $\mu\text{L}$ , 2.0 mmol) and  $\text{NH}_4\text{Cl}$  (183 mg, 3.4 mmol) and stirred for 3 h. The mixture is diluted with saturated NaCl (50 mL) and extracted with EtOAc (3 x 20 mL). The combined organics are washed with 2N HCl (2 x 10 mL), followed by water (2 x 10 mL), saturated  $\text{NaHCO}_3$  (2 x 10 mL) and additional  $\text{H}_2\text{O}$  (2 x 10 mL) then dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated to afford 177 mg (81%) of methyl 2-(aminocarbonyl)-1-benzofuran-6-carboxylate as an orange-brown solid. HRMS (FAB) calcd for  $\text{C}_{11}\text{H}_9\text{NO}_4 + \text{H}$ : 220.0610, found 220.0603 (M+H) $^+$ .

30 Methyl 2-(aminocarbonyl)-1-benzofuran-6-carboxylate (164 mg, 0.75 mmol) is dissolved in MeOH (5 mL) and water (1 mL), treated drop-wise with 2N NaOH (450

$\mu\text{L}$ , 0.9 mmol) and monitored by TLC. The volatiles are removed *in vacuo*, and the resulting tan solid is dissolved in water (5 mL) and acidified to pH 3 with concentrated HCl. The resulting solid is collected via filtration and dried in a vacuum oven with heat 50°C to afford 142 mg (93%) of 2-(aminocarbonyl)-1-benzofuran-6-carboxylic acid as an orange solid. HRMS (EI) calcd for  $\text{C}_{10}\text{H}_7\text{NO}_4$ : 205.0375, found 205.0378 ( $\text{M}$ )<sup>+</sup>.

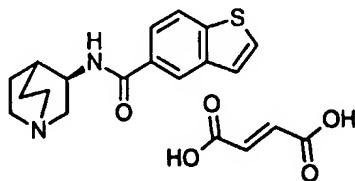
2-(Aminocarbonyl)-1-benzofuran-6-carboxylic acid (131 mg, 0.64 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (140 mg, 0.7 mmol) according to Method A to afford 174 mg (87%) of Example 10 as a pale yellow solid. HRMS (FAB) calcd for  $\text{C}_{17}\text{H}_{19}\text{N}_3\text{O}_3 + \text{H}$ : 314.1505, found 314.1502 ( $\text{M} + \text{H}$ )<sup>+</sup>.

**Example 11:** *N*-[(3R)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-6-carboxamide•fumarate:



1-Benzothiophene-6-carboxylic acid [see: Badger et al. *J.Chem.Soc.* **1957**, 2624, 2628] is coupled with (R)-3-aminoquinuclidine dihydrochloride according to Method C making non-critical changes to give the free base as a white solid (260 mg, 95%) and Example 11 as a white solid (260 mg, 71%): <sup>1</sup>H NMR (400 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.48, 7.95, 7.87, 7.80, 7.48, 6.71, 4.52-4.45, 3.89-3.80, 3.50-3.25, 2.41-2.36, 2.33-2.23, 2.15-2.08, 2.00-1.88.

**Example 12:** *N*-[(3R)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide•fumarate:

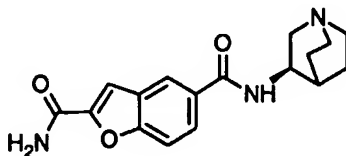


1-Benzothiophene-5-carboxylic acid is coupled with (R)-3-aminoquinuclidine dihydrochloride according to Method C making non-critical changes to give the free

base as a white solid (256 mg, 90%) and Example 12 as a white solid (260 mg, 71%):

$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.40, 8.03, 7.84, 7.71, 7.50, 6.71, 4.50-4.45, 3.90-3.82, 3.52-3.28, 2.40-2.36, 2.33-2.21, 2.16-2.08, 2.01-1.90.

5 **Example 13:** *N'*5'-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,5-dicarboxamide:

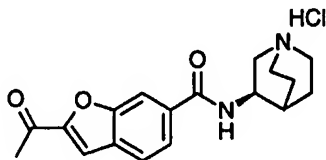


Methyl 2-cyano-1-benzofuran-5-carboxylate (426 mg, 2.0 mmol) is dissolved in MeOH (10 ml). The solution is cooled to 0°C, is treated with LiOH monohydrate (168 mg, 4.0 mmol) in H<sub>2</sub>O (4 ml), and the reaction is stirred 6 h at RT. The volatiles are removed *in vacuo* and the residue is dissolved in H<sub>2</sub>O (10 ml). The pH of the mixture is adjusted to 1.9 with 12N HCl, the white solid is collected, washed with water, and is dried to give 401 mg (97%) of 2-(aminocarbonyl)-1-benzofuran-5-carboxylic acid as an off-white solid. MS (EI) calcd for C<sub>10</sub>H<sub>7</sub>NO<sub>4</sub>: 205.0375, found 15 205.0369 (M)<sup>+</sup>.

2-(Aminocarbonyl)-1-benzofuran-5-carboxylic acid (350 mg, 1.7 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (374 mg, 1.9 mmol) according to Method A to afford 120 mg (23%) of Example 13 as white solid. HRMS (ESI) calcd for C<sub>17</sub>H<sub>19</sub>N<sub>3</sub>O<sub>3</sub> +H: 314.1505, found 314.1513 (M+H)<sup>+</sup>.

20

**Example 14:** 2-Acetyl-*N'*[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide hydrochloride:



Methyl 2-formyl-1-benzofuran-6-carboxylate (750 mg, 3.67 mmol) is dissolved in anhydrous THF (30 ml) in a dry flask under nitrogen and cooled to 0°C. Methyl magnesium bromide (2.6 ml, 3.67 mmol) is added via syringe, and the reaction is stirred overnight, allowing the ice bath to expire. The reaction is quenched with 5% HCl (70 ml) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 25 ml). The combined organics



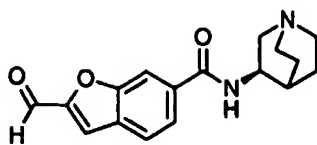
are dried ( $\text{MgSO}_4$ ), filtered, and concentrated to a yellow oil. The crude material is chromatographed over 100 g slurry-packed silica gel, eluting with 35% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 412 mg (51%) of methyl 2-(1-hydroxyethyl)-1-benzofuran-6-carboxylate as a yellow oil  
5 that solidified upon standing. MS for  $\text{C}_{12}\text{H}_{12}\text{O}_4$ , (EI)  $m/z$ : 220 (M)<sup>+</sup>.

Oxalyl chloride (0.1 ml, 1.15 mmol) is dissolved in  $\text{CH}_2\text{Cl}_2$  (2 ml) in a dry flask under nitrogen and cooled to  $-78^\circ\text{C}$ . DMSO (0.16 ml, 2.3 mmol) is added drop-wise, and the mixture stirred for 30 min, while maintaining the temperature. Methyl 2-(1-hydroxyethyl)-1-benzofuran-6-carboxylate (220 mg, 1.0 mmol) is dissolved in  
10  $\text{CH}_2\text{Cl}_2$  (2 ml) and added drop-wise to the mixture, and the solution stirred for 1 h at  $-78^\circ\text{C}$ . TEA (0.69 ml, 5.0 mmol), is added drop-wise and the reaction is stirred for an additional 30 min. The reaction is then warmed to  $0^\circ\text{C}$  and stirred for another 30 min. The reaction is washed with saturated  $\text{NaHCO}_3$  (40 ml), and the organics are dried ( $\text{K}_2\text{CO}_3$ ), filtered, and concentrated to a yellow solid. The crude material is  
15 chromatographed over 25 g slurry-packed silica gel, eluting with 20% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 174 mg (80%) of methyl 2-acetyl-1-benzofuran-6-carboxylate as a pale yellow solid. HRMS (FAB) calcd for  $\text{C}_{12}\text{H}_{10}\text{O}_4+\text{H}$ : 219.0657, found 219.0667 (M+H)<sup>+</sup>.

Methyl 2-acetyl-1-benzofuran-6-carboxylate (155 mg, 0.71 mmol) is dissolved  
20 in MeOH (3 ml) and  $\text{H}_2\text{O}$  (0.5 ml). 2N NaOH (0.39 ml, 0.78 mmol) is added drop-wise, and the reaction is stirred overnight. The volatiles are removed *in vacuo*, and the residue is dissolved in  $\text{H}_2\text{O}$  (3 ml). Concentrated HCl is used to adjust the pH to 3, and the resulting precipitate is isolated via filtration and dried overnight to afford 135 g (93%) of 2-acetyl-1-benzofuran-6-carboxylic acid as a yellow solid. MS for  
25  $\text{C}_{11}\text{H}_8\text{O}_4$ , (ESI-).  $m/z$ : 202.7 (M-H)<sup>-</sup>.

2-Acetyl-1-benzofuran-6-carboxylic acid (130 mg, 0.64 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (140 mg, 0.70 mmol) and salt made according to Method A with non-critical variations to afford 176 mg (79%) of Example 14 as a yellow solid. HRMS (FAB) calcd for  $\text{C}_{18}\text{H}_{20}\text{N}_2\text{O}_3+\text{H}$ : 313.1552,  
30 found 313.1552 (M+H)<sup>+</sup>.

**Example 15:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide:

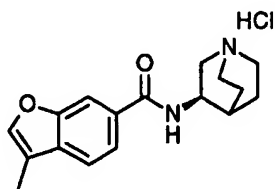


Methyl 2-(diethoxymethyl)-1-benzofuran-6-carboxylate (417 mg, 1.5 mmol) is dissolved in MeOH (8 ml) and H<sub>2</sub>O (2 ml). 2N NaOH (0.9 ml, 1.8 mmol) is added drop-wise, and the reaction is stirred for 4 days. The volatiles are removed *in vacuo* and the residue is dissolved in H<sub>2</sub>O (2 ml). Concentrated HCl is used to adjust the pH to 3, and the resulting precipitate is isolated via filtration and dried overnight to afford 410 mg (>100%, water present) of 2-(diethoxymethyl)-1-benzofuran-6-carboxylic acid as a brown solid. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 1.29, 3.72, 6.9, 7.66, 8.04, 8.29 ppm.

2-(Diethoxymethyl)-1-benzofuran-6-carboxylic acid (264 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) and salt made according to Method A with non-critical changes to afford 286 mg (70%) of *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-(diethoxymethyl)-1-benzofuran-6-carboxamide hydrochloride as a white solid. HRMS (FAB) calcd for C<sub>21</sub>H<sub>28</sub>N<sub>2</sub>O<sub>4</sub>+H: 373.2127, found 373.2121 (M+H)<sup>+</sup>.

*N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-2-(diethoxymethyl)-1-benzofuran-6-carboxamide hydrochloride (100 mg, 0.24 mmol) is dissolved in formic acid (1 ml, 26 mmol), treated drop-wise with H<sub>2</sub>O (0.25 ml) and stirred overnight. The volatiles are removed *in vacuo*, the residue treated carefully with saturated NaHCO<sub>3</sub> (5 ml) and stirred for 15 min. The precipitate is isolated via filtration and the cake dried overnight to yield 58 mg (80%) of Example 15 as a light tan solid. HRMS (FAB) calcd for C<sub>17</sub>H<sub>18</sub>N<sub>2</sub>O<sub>3</sub>+H: 299.1396, found 299.1402 (M+H)<sup>+</sup>.

**Example 16:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide hydrochloride:



Methyl 3-hydroxy-4-iodobenzoate (2.0 g, 7.2 mmol) is dissolved in DMF (25 ml) in a dry flask under nitrogen. Allyl bromide (0.65 ml, 7.55 mmol) is added drop-

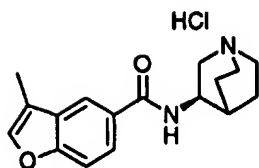
wise, followed by the careful addition of 60% NaH (303 mg, 7.55 mmol). The reaction is stirred overnight at RT and then is diluted with H<sub>2</sub>O (30 ml). The mixture is extracted with EtOAc (3 x 30 ml), and the combined organics are washed with 50% saturated NaCl (4 x 25 ml), dried (MgSO<sub>4</sub>), filtered, and concentrated under high vacuum to an oil that solidified upon standing. The volatiles are removed *in vacuo* to obtain 2.28 g (100%) of methyl 3-(allyloxy)-4-iodobenzoate as a tan solid. HRMS (FAB) calcd for C<sub>11</sub>H<sub>11</sub>IO<sub>3</sub>+H: 318.9833, found 318.9831 (M+H)<sup>+</sup>.

Methyl 3-(allyloxy)-4-iodobenzoate (2.0 g, 6.28 mmol) is dissolved in DMF (15 ml), treated with Pd(OAc)<sub>2</sub> (71 mg, 0.31 mmol), Na<sub>2</sub>CO<sub>3</sub> (1.67 g, 15.7 mmol), sodium formate (427 mg, 6.28 mmol), and *n*-Bu<sub>4</sub>NCl·H<sub>2</sub>O (1.92 g, 6.92 mmol) and stirred at 80°C for 2 days. The mixture is then filtered, the liquor is diluted with EtOAc (75 ml) and washed with 50% saturated NaCl (4 x 25 ml) followed by 5% HCl (25 ml). The organic layer is dried (Na<sub>2</sub>SO<sub>4</sub>), filtered, and concentrated to a brown oil. The crude material is chromatographed over 50 g slurry-packed silica gel, eluting with 20% EtOAc/hexane. The appropriate fractions are combined and concentrated to afford 797 mg (67%) of methyl 3-methyl-1-benzofuran-6-carboxylate as a pale oil. HRMS (FAB) calcd for C<sub>11</sub>H<sub>10</sub>O<sub>3</sub>+H: 191.0708, found 191.0714 (M+H)<sup>+</sup>.

Methyl 3-methyl-1-benzofuran-6-carboxylate (720 mg, 3.78 mmol) is dissolved in MeOH (10 ml), treated with 2N NaOH (2.27 ml, 4.5 mmol) and stirred overnight. The volatiles are removed *in vacuo*, the residue is dissolved in H<sub>2</sub>O (5 ml) and the pH is adjusted to 3 with concentrated HCl. The mixture is stirred overnight and the resulting solid is filtered to afford 545 mg (82%) of 3-methyl-1-benzofuran-6-carboxylic acid as a white solid. HRMS (FAB) calcd for C<sub>10</sub>H<sub>8</sub>O<sub>3</sub>+H: 177.0552, found 177.0551 (M+H)<sup>+</sup>.

3-Methyl-1-benzofuran-6-carboxylic acid (176 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) and salt made according to Method A with non-critical variations to afford 244 mg (76%) of Example 16 as a white solid. HRMS (FAB) calcd for C<sub>17</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub>+H: 285.1603, found 285.1616 (M+H)<sup>+</sup>.

**Example 17:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide hydrochloride:



Methyl 4-hydroxy-3-iodobenzoate (1.85 g, 6.65 mmol) is dissolved in anhydrous DMF (15 mL) in a dry flask under nitrogen, treated with NaH (60% dispersion in oil, 265 mg, 6.65 mmol) and stirred for 1 h at RT. Allyl bromide (633  $\mu$ L, 7.32 mmol) is added and the mixture is stirred for 16 h. The mixture is concentrated and the residue is partitioned between EtOAc (25 mL) and H<sub>2</sub>O (25 mL). The organic layer is washed with a 50% saturated mixture of 1:1 NaC/NaHCO<sub>3</sub> (2 x 10 mL), dried (MgSO<sub>4</sub>) and concentrated to a yellow oil which solidified to a white solid upon standing (2.12 g). The crude material is chromatographed over 100 g slurry-packed silica gel, eluting with 10% EtOAc/hexane. The appropriate fractions are combined and concentrated to afford 1.27 g (60%) of methyl 4-(allyloxy)-3-iodobenzoate as a colorless oil which solidified on standing. MS for C<sub>11</sub>H<sub>11</sub>IO<sub>3</sub> (EI)  $m/z$ : 318 (M)<sup>+</sup>.

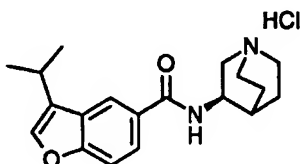
Methyl 4-(allyloxy)-3-iodobenzoate (587 mg, 1.84 mmol) is combined with Pd(OAc)<sub>2</sub> (5%, 20 mg, 0.1 mmol), Na<sub>2</sub>CO<sub>3</sub> (487 mg, 4.6 mmol), sodium formate (125 mg, 1.8 mmol) and *n*-Bu<sub>4</sub>NCl·H<sub>2</sub>O (561 mg, 2.0 mmol) in DMF (5 mL) and heated to 80°C for 2 days. The mixture is concentrated under high vacuum and partitioned between 50% saturated NaCl (10 mL) and CH<sub>2</sub>Cl<sub>2</sub> (4 x 10 mL). The combined organics are washed with 5% HCl (10 mL), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated to a brown oil. The crude material is chromatographed over 15 g slurry-packed silica gel, eluting with 15% EtOAc/hexane. The appropriate fractions are combined and concentrated to afford 153 mg (44%) of methyl 3-methyl-1-benzofuran-5-carboxylate as a white solid. HRMS (FAB) calcd for C<sub>11</sub>H<sub>10</sub>O<sub>3</sub> +H: 191.0708, found: 191.0705 (M+H)<sup>+</sup>.

Methyl 3-methyl-1-benzofuran-5-carboxylate (365 mg, 1.9 mmol) is dissolved in MeOH (7 mL), diluted with H<sub>2</sub>O (3.5 mL) and treated with 3N NaOH (1.41 mL, 4.2 mmol). The mixture is diluted with MeOH (3.5 mL) to homogeneity, stirred at RT for 2.5 days then concentrated to dryness. The residue is dissolved in H<sub>2</sub>O (5 mL) and acidified to pH 2 with concentrated HCl. The resulting solid is filtered and dried in a vacuum oven at 40°C for 18 h to afford 321 mg (95%) of 3-methyl-1-benzofuran-

5-carboxylic acid as a white solid. HRMS (FAB) calcd for  $C_{10}H_8O_3 + H$ : 177.0552, found: 177.0553 (M+H)<sup>+</sup>.

3-Methyl-1-benzofuran-5-carboxylic acid (156 mg, 0.88 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (193 mg, 0.97 mmol) and salt made according to Method A with non-critical variations to afford 235 mg (83%) of Example 17 as a white solid. HRMS (FAB) calcd for  $C_{17}H_{20}N_2O_2 + H$ : 285.1603, found 285.1613 (M+H)<sup>+</sup>.

**Example 18:** N-[(3R)-1-Azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide hydrochloride:

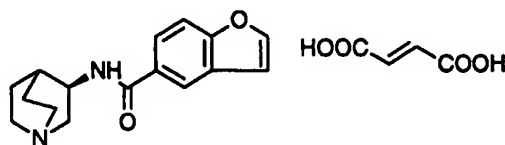


Methyl 4-hydroxy-3-iodobenzoate (6.0 g, 21.5 mmol) is dissolved in DMF (35 ml) in a dry flask under nitrogen and cooled to 0°C. NaH (60% dispersion in oil, 860 mg, 21.5 mmol) is added portion-wise and the reaction is stirred for 1 h, allowing the ice bath to expire. The mixture is then treated with 1-chloro-3-methyl-2-butene (2.67 ml, 23.7 mmol) and NaI (323 mg, 2.15 mmol), and the reaction is stirred for 18 h at RT. The mixture is diluted with EtOAc (150 ml) and washed with 1:1 saturated NaCl/NaHCO<sub>3</sub> (100 ml). The organic layer is dried (MgSO<sub>4</sub>), concentrated to an oil and chromatographed over 700 g slurry-packed silica gel, eluting with 15% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 5.13 g of a pale oil. The dimethylallyl ether is dissolved in DMF (40 ml) and treated successively with Pd(OAc)<sub>2</sub> (165 mg, 0.74 mmol), Na<sub>2</sub>CO<sub>3</sub> (3.9 g, 36.8 mmol), sodium formate (1.0 g, 14.7 mmol), and *n*-Bu<sub>4</sub>NCl·H<sub>2</sub>O (4.5 g, 16.2 mmol). The mixture is stirred for 2 days at 80°C, then diluted with EtOAc (200 ml) and washed with 50% saturated NaCl (3 x 75 ml) followed by 5% HCl (75 ml). The organic layer is dried (MgSO<sub>4</sub>), filtered and concentrated to a brown oil. The crude material is chromatographed over 250 g slurry-packed silica gel, eluting with 10% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 1.33 g (28% over 2 steps) of methyl 3-isopropyl-1-benzofuran-5-carboxylate as an oil. HRMS (FAB) calcd for  $C_{13}H_{14}O_3 + H$ : 219.1021, found 219.1021 (M+H)<sup>+</sup>.

Methyl 3-isopropyl-1-benzofuran-5-carboxylate (1.20 g, 5.51 mmol) is dissolved in MeOH (20 ml) and water (4 ml), treated drop-wise with 2N NaOH (3.3 ml, 6.6 mmol) and stirred at RT for 2 days, then at 40°C for 4 h. The volatiles are removed *in vacuo*, the residue is dissolved in water (10 ml) and the pH is adjusted to 3 with concentrated HCl. The resulting precipitate is isolated via filtration and dried overnight to afford 1.08 g (97%) of 3-isopropyl-1-benzofuran-5-carboxylic acid as a white solid. MS (ESI-) for C<sub>12</sub>H<sub>12</sub>O<sub>3</sub> *m/z*: 203.0 (M-H)<sup>-</sup>.

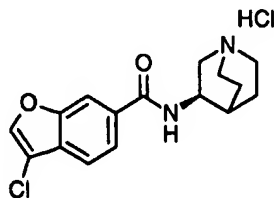
3-Isopropyl-1-benzofuran-5-carboxylic acid (204 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) and salt made according to Method A with non-critical variations to afford 313 mg (90%) of Example 19 as a white solid. HRMS (FAB) calcd for C<sub>19</sub>H<sub>24</sub>N<sub>2</sub>O<sub>2</sub>+H: 313.1916, found 313.1913 (M+H)<sup>+</sup>.

**Example 19:** *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide•fumarate:



1-Benzofuran-5-carboxylic acid is coupled with (R)-3-aminoquinuclidine dihydrochloride according to Method C making non-critical changes to give the free base as a white solid (1.1 g, 95%) and Example 19 as a white solid (1.5 g, 92%): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.20, 7.88, 7.85, 7.61, 6.97, 6.70, 4.50-4.43, 3.89-3.80, 3.50-3.23, 2.40-2.34, 2.32-2.21, 2.16-2.08, 2.00-1.89.

**Example 20:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide hydrochloride:



Methyl 3-hydroxy-4-[(trimethylsilyl)ethynyl]benzoate (4.15 g, 16.7 mmol) is dissolved in MeOH (45 ml) and treated with DIA (2.34 ml, 16.7 mmol). Copper

iodide (159 mg, 0.84 mmol) is added portion-wise and the reaction is heated at 75°C for 3 h. DARCO (2 g) is added and the reaction is stirred at 95°C for an additional 2h, then overnight at RT. The reaction is filtered, concentrated to a brown oil and the crude material is chromatographed over 300 g slurry-packed silica gel, eluting with 10% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 2.05 g (70%) of methyl 1-benzofuran-6-carboxylate as an orange crystalline solid. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 3.97, 6.84, 7.65, 7.78, 7.98, 8.22 ppm.

Methyl 1-benzofuran-6-carboxylate (1.90 g, 10.7 mmol) is dissolved in Et<sub>2</sub>O (50 ml) and cooled to 0°C. Chlorine gas is bubbled in for 5 min, and the reaction is stirred over the weekend, allowing the ice bath to expire. The volatiles are removed *in vacuo*, and the crude material is chromatographed over 300 g slurry-packed silica gel, eluting with 10% EtOAc/hexane. The appropriate fractions are collected and concentrated to afford 906 mg (34%) of *cis*-methyl 2,3-dichloro-2,3-dihydro-1-benzofuran-6-carboxylate as a pale oil. A second pool of fractions is collected and concentrated to afford 1.25 g (47%) of *trans*-methyl 2,3-dichloro-2,3-dihydro-1-benzofuran-6-carboxylate and as a yellow oil.

*trans*- isomer: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 3.93, 5.47, 6.53, 7.56, 7.69, 7.85 ppm.

*cis*- isomer: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 3.94, 5.68, 6.69, 7.49, 7.63, 7.85 ppm

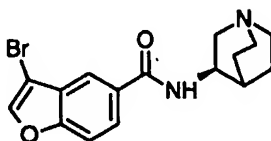
*trans*-Methyl 2,3-dichloro-2,3-dihydro-1-benzofuran-6-carboxylate (58 mg, 0.23 mmol) is dissolved in EtOH (2 ml), treated with K<sub>2</sub>CO<sub>3</sub> (187 mg, 1.35 mmol) and stirred at RT overnight. The mixture is concentrated to dryness, the residue is dissolved in 50% saturated NaCl (10 ml) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 10 ml). The combined organics are dried (K<sub>2</sub>CO<sub>3</sub>), filtered, and concentrated *in vacuo* to a yellow oil. The crude material is chromatographed over 10 g slurry-packed silica gel, eluting with 25% EtOAc/hexane. The appropriate fractions are combined and concentrated to afford 30 mg (58%) of ethyl 3-chloro-1-benzofuran-6-carboxylate as a yellow oil. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 1.44, 4.43, 7.66, 7.79, 8.07, 8.21 ppm.

Ethyl 3-chloro-1-benzofuran-6-carboxylate (110 mg, 0.49 mmol) is dissolved in MeOH (3 ml) and water (0.75 ml), treated drop-wise with 2N NaOH (0.27 ml, 0.54 mmol) and stirred overnight at RT. The volatiles are removed *in vacuo*, the residue is dissolved in water (3 ml) and the pH is adjusted to 3 with concentrated HCl. The resulting solid is filtered and dried overnight in a vacuum oven to afford 88 mg (92%)

of 3-chloro-1-benzofuran-6-carboxylic acid as a white solid. MS for  $C_9H_5ClO_3$  (EI)  $m/z$ : 196 (M)<sup>+</sup>.

3-Chloro-1-benzofuran-6-carboxylic acid (75 mg, 0.38 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (84 mg, 0.42 mmol) and salt made according to Method A with non-critical variations to afford 116 mg (89%) of Example 20 as an ivory-colored solid. HRMS (FAB) calcd for  $C_{16}H_{17}ClN_2O_2 + H$ : 305.1057, found 305.1043 (M+H)<sup>+</sup>.

**Example 21:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide:



Methyl 4-hydroxy-3-[(trimethylsilyl)ethynyl]benzoate (11 g, 44.5 mmol) is combined with DIA (7.1 ml, 50 mmol) and cuprous iodide (423 mg, 2.2 mmol) in 100 ml MeOH in a flask under nitrogen. The reaction is warmed to 60°C for 6 h, the volatiles are removed *in vacuo*, and the brown-green residue is chromatographed over 500 g silica gel (230–400 mesh) eluting with 20 % EtOAc/hexane. The appropriate fractions are combined and concentrated to give 2.63 g (34%) of methyl benzofuran-5-carboxylate as a pale oil which crystallized on standing. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 3.95, 6.86, 7.53, 7.70, 8.03, 8.36 ppm.

Methyl benzofuran-5-carboxylate (1.74 g, 9.9 mmol) is dissolved in CH<sub>2</sub>Cl<sub>2</sub> (50 mL), layered with saturated NaHCO<sub>3</sub> (75 mL) using very slow magnetic stirring so that the two layers are not mixed and treated with Br<sub>2</sub> (3.1 mL, 59.1 mmol). The bi-phasic mixture is stirred slowly for 2 h, then vigorously for 1 h. The layers are separated and the aqueous layer is extracted with CH<sub>2</sub>Cl<sub>2</sub> (2 x 50 mL). The organics are dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated under reduced pressure without heat. The residue is dissolved in MeOH (100 mL), treated with K<sub>2</sub>CO<sub>3</sub> (8.17 g, 59.1 mmol) and stirred at RT for 18 h. The mixture is concentrated to dryness, partitioned between 50% saturated NaHCO<sub>3</sub> (75 mL) and EtOAc (2 x 75 mL) and the organics are dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo*. The crude material (2.21 g) is adsorbed onto silica gel (4.5 g) chromatographed over 90 g slurry-packed silica gel, eluting with 8% EtOAc/hexane then 15% EtOAc/hexane. The appropriate fractions are combined and



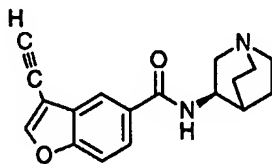
concentrated to afford 1.88 g (75%) of methyl 3-bromo-1-benzofuran as a white solid.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  3.99, 7.55, 7.74, 8.11, 8.31 ppm.

Methyl benzofuran-5-carboxylate (667 mg, 3.8 mmol) is dissolved in 20 ml  $\text{CH}_2\text{Cl}_2$  in a flask under nitrogen. The solution is treated with  $\text{Br}_2$  (1.2 ml, 22.8 mmol), is layered with 20 ml saturated  $\text{NaHCO}_3$ , and the reaction is stirred gently for 2 h at RT. The reaction is stirred vigorously for 30 min, the layers are separated, and the organic layer is concentrated *in vacuo* to an amber oil. The residue is dissolved in 30 ml EtOH, the solution is treated with anhydrous  $\text{K}_2\text{CO}_3$  (3.15 g, 22.8 mmol), and the reaction is stirred vigorously overnight. The insoluble material is removed by filtration and the filtrate is diluted with 3 ml 3N NaOH and the mixture is stirred 3 h at RT. The mixture is concentrated *in vacuo*, the residue is dissolved in 10 ml  $\text{H}_2\text{O}$ , and the pH of the solution is adjusted to 2 with 10% aqueous HCl. The precipitate is collected, washed with water, and is dried to afford 880 mg (96%) of 3-bromobenzofuran-5-carboxylic acid as an off-white solid. HRMS (FAB) calcd for  $\text{C}_9\text{H}_5\text{BrO}_3 + \text{H}$ : 240.9501, found 240.9505 ( $\text{M} + \text{H}$ ) $^+$ .

3-Bromo-1-benzofuran-5-carboxylic acid (241 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) according to Method A to afford 280 mg (80%) of Example 21 as an off-white solid. HRMS (ESI) calcd for  $\text{C}_{16}\text{H}_{17}\text{BrN}_2\text{O}_2 + \text{H}$ : 349.0552, found 349.0555 ( $\text{M} + \text{H}$ ) $^+$ .

20

**Example 22:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide:



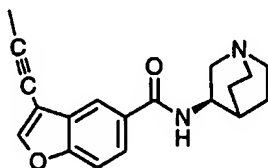
*N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide (350 mg, 1.0 mmol) is combined with bis(benzonitrile)palladium dichloride (57 mg, 0.15 mmol), cuprous iodide (19 mg, 0.10 mmol), tri(*t*-butyl)phosphine (658  $\mu\text{L}$ , 0.325 mmol), trimethylsilylacetylene (170  $\mu\text{L}$ , 1.2 mmol), and DIA (168  $\mu\text{L}$ , 1.2 mmol) in dioxane (3 ml) in a dry flask under nitrogen. The reaction is stirred overnight at RT, is diluted with EtOAc (25 ml), is washed with 1:1:0.1 NaCl/water/conc.  $\text{NH}_4\text{OH}$  (4 x 25 ml), and the organic layer is dried ( $\text{K}_2\text{CO}_3$ ). The volatiles are removed *in vacuo*

30

and the residue is chromatographed over 30 g silica gel (230–400 mesh) eluting with 7% MeOH/CHCl<sub>3</sub> + 1% conc. NH<sub>4</sub>OH. The appropriate fractions are combined and concentrated to afford 268 mg (73%) of N-[(3R)-1-azabicyclo[2.2.2]oct-3-yl]-3-[(trimethylsilyl)ethynyl]-1-benzofuran-5-carboxamide as a pale foam. HRMS (ESI) calcd for C<sub>21</sub>H<sub>26</sub>N<sub>2</sub>O<sub>2</sub>SI +H: 367.1841, found 367.1852 (M+H)<sup>+</sup>.

N-[(3R)-1-Azabicyclo[2.2.2]oct-3-yl]-3-[(trimethylsilyl)ethynyl]-1-benzofuran-5-carboxamide (255 mg, 0.70 mmol) is dissolved in MeOH (6 ml). The solution is treated with saturated NaHCO<sub>3</sub> (2 ml) and the reaction is stirred overnight at RT. The volatiles are removed *in vacuo* and the residue is chromatographed over 30 g silica gel (230–400 mesh) eluting with 8% MeOH/CHCl<sub>3</sub>+ 1% conc. NH<sub>4</sub>OH. The appropriate fractions are combined and concentrated to give 190 mg of a yellow foam. The foam is crystallized from Et<sub>2</sub>O to provide 138 mg (67%) of Example 22 as a pale yellow solid. HRMS (ESI) calcd for C<sub>18</sub>H<sub>18</sub>N<sub>2</sub>O<sub>2</sub> +H: 295.1446, found 295.1458 (M+H)<sup>+</sup>.

**Example 23:** N-[(3R)-1-Azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide:

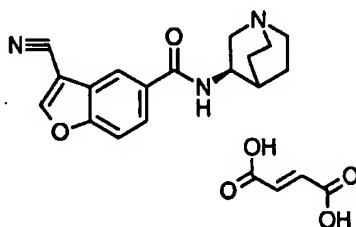


Methyl 3-bromobenzofuran-5-carboxylate (750 mg, 2.94 mmol) is combined with bis(benzonitrile)palladium dichloride (169 mg, 0.44 mmol), cuprous iodide (19 mg, 0.10 mmol), tri-*t*-butylphosphine ((10% in hexane) 1.92 ml, 0.95 mmol), and propyne (2 ml, 35 mmol) in 7 ml dry dioxane in 15 ml screw cap pressure tube under nitrogen. The mixture is treated with DIA (494 μL, 3.6 mmol), is stirred overnight at RT, and is diluted with 50 ml EtOAc. The reaction is washed with 4 x 25 ml 1:1:0.1 H<sub>2</sub>O/brine/conc. NH<sub>4</sub>OH, the organic layer is dried (MgSO<sub>4</sub>), and the volatiles are removed *in vacuo*. The crude material is chromatographed over 50 g silica gel (230–400 mesh) eluting with 12% EtOAc/hexane. The appropriate fractions are combined and concentrated to give 460 mg (73%) of methyl 3-prop-1-ynyl-1-benzofuran-5-carboxylate as a pale solid. MS for C<sub>13</sub>H<sub>10</sub>O<sub>3</sub> (EI) *m/z* (rel. intensity): 214 (M)<sup>+</sup>.

Methyl 3-prop-1-ynyl-1-benzofuran-5-carboxylate (388 mg, 1.81 mmol) is dissolved in 10 ml MeOH. The solution is treated with 2N NaOH (2.3 ml, 4.6 mmol) followed by 2 ml H<sub>2</sub>O and the reaction is stirred overnight at RT. The reaction is concentrated to dryness, the residue is dissolved in 9 ml H<sub>2</sub>O, and the pH is adjusted to 3 with 10% aqueous HCl. The precipitate is collected, washed with H<sub>2</sub>O, and is dried to afford 356 mg (98%) of 3-prop-1-ynyl-1-benzofuran-5-carboxylic acid as an off-white solid. HRMS (EI) calcd for C<sub>12</sub>H<sub>8</sub>O<sub>3</sub>: 200.0473, found 200.0476 (M<sup>+</sup>).

3-Prop-1-ynyl-1-benzofuran-5-carboxylic acid (178 mg, 1.0 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (219 mg, 1.1 mmol) according to Method A to afford 200 mg (65%) of Example 23 as an off-white solid. HRMS (ESI) calcd for C<sub>19</sub>H<sub>20</sub>N<sub>2</sub>O<sub>2</sub> +H: 309.1603, found 309.1599 (M+H)<sup>+</sup>.

**Example 24:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide•fumarate:



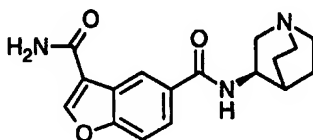
15

A mixture of ethyl and methyl 3-bromo-1-benzofuran-5-carboxylate (778 mg, 3.0 mmol) is combined with zinc cyanide (211 mg, 1.8 mmol), tris(dibenzylideneacetone)dipalladium (110 mg, 0.12 mmol), 1,1'-bis(diphenylphosphino)ferrocene (132 mg, 0.24 mmol) and zinc dust (46 mg, 0.72 mmol) in a dry flask under nitrogen. The vessel is purged with nitrogen, treated with dimethyl acetamide (6 mL) and heated to 120°C for 18 h. The mixture is cooled to RT diluted with EtOAc (50 mL), filtered through celite and washed with 2N NH<sub>4</sub>OH (2 x 50 mL). The organics are further washed with NaCl (50 mL), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated to a brown solid (763 mg). The crude material is chromatographed over 30 g slurry-packed silica gel, eluting with 12% EtOAc/hexane. The appropriate fractions are combined and concentrated to afford 280 mg (45%) of the mixed methyl and ethyl esters as a yellow solid (45% ethyl ester/55% methyl ester). The mixture of ethyl and methyl 3-cyano-1-benzofuran-5-carboxylate (270 mg, 1.3 mmol) is suspended in pH 7 buffer (11 mL), treated with a solution of pig liver esterase (64 mg)

in pH 7 buffer (4 mL) and stirred vigorously at RT for 16 h. Acetone (2 mL) is added, the mixture is stirred for 24 h and filtered through celite. The filtrate is acidified to pH 2 with concentrated HCl. The resulting solid is stirred for 45 min, filtered and dried in a vacuum oven at 80°C for 16 h to afford 100 mg (41%) of 3-cyano-1-benzofuran-5-carboxylic acid as a white solid. MS for  $C_{10}H_5NO_3$ , (EI)  $m/z$ : 187 (M)<sup>+</sup>.

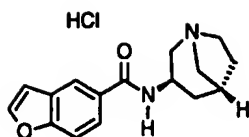
3-Cyano-1-benzofuran-5-carboxylic acid (94 mg, 0.5 mmol) is coupled with (R)-3-aminoquinuclidine dihydrochloride (109 mg, 0.55 mmol) according to Method A. The free base (123 mg) is combined with fumaric acid (48 mg, 0.41 mmol) in MeOH (0.7 mL) and the fumarate salt is precipitated upon addition of EtOAc (7ml). The solid is collected, rinsed with Et<sub>2</sub>O, and dried in a vacuum oven at 60°C to afford 126 mg (61%) of Example 24 as a white solid. HRMS (FAB) calcd for  $C_{17}H_{17}N_3O_2$  +H: 296.1399, found 296.1403 (M+H)<sup>+</sup>.

**Example 25:** *N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,5-dicarboxamide:



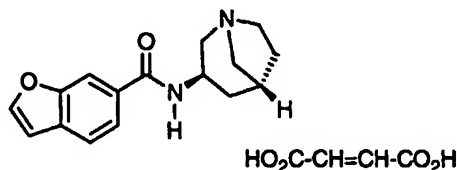
*N*-[(3*R*)-1-Azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide (148 mg, 0.5 mmol) is dissolved in conc. H<sub>2</sub>SO<sub>4</sub> (0.5 mL, 18 mmol) and water (50  $\mu$ L) and stirred at RT for 4.5 h. The pH is adjusted to 12 with 10N NaOH and the resulting solid filtered and rinsed with acetone. The filtrate is extracted with 10% MeOH/CHCl<sub>3</sub> (6 x 20 mL) and the organics are dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated to a white foam (173 mg). The foam is triturated with Et<sub>2</sub>O, the resulting solid filtered, and dried in a vacuum oven at 50°C to afford 99 mg (63%) of Example 25 as an off-white solid. HRMS (ESI) calcd for  $C_{17}H_{19}N_3O_3$  +H: 314.1505, found 314.1502 (M+H)<sup>+</sup>.

**Example 26:** *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide hydrochloride:



1-Benzofuran-5-carboxylic acid (0.177 g) is coupled with (3*R*,5*R*)-[3.2.1]-Amine (0.221 g) using Method A, making non-critical changes to afford 0.267 g of Example 26 as an off-white foam: <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) δ 10.67, 8.50-8.60, 8.32; 8.18, 7.82, 7.69, 7.08, 4.40-4.60, 3.05-3.60, 2.65-2.75, 2.05-2.20, 1.85-2.00.

**Example 27:** *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide fumarate:

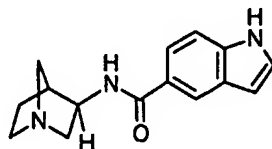


10

1-Benzofuran-5-carboxylic acid (0.762 g) is coupled with (3*R*,5*R*)-[3.2.1]-Amine (0.620 g) using Method A, making non-critical changes. The free base is treated with EtOH/fumaric acid, heated, partially evaporated, collected by filtration and dried *in vacuo* to afford 0.477 g of Example 27 as an off-white solid: <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) δ 8.30-8.40, 8.10-8.15, 8.08, 7.70-7.80, 7.00-7.05, 6.51, 4.30-4.45, 3.00-3.45, 2.75-2.95, 1.65-2.00.

15

**Example 28:** *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-5-carboxamide:



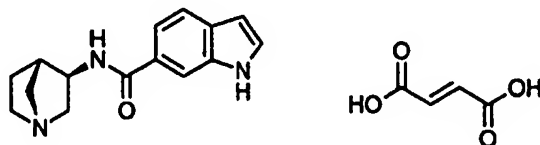
20 Method B

To a stirred solution of 1*H*-indole-5-carboxylic acid (80.6 mg, 0.5 mmol) in DMF (10 mL) are added DIEA (265 μL, 1.52 mmol) and *exo*-[2.2.1]-Amine (228 mg, 0.5 mmol). The mixture is cooled to 0°C in an ice bath, and HATU (190 mg, 0.5 mmol) is added in one portion. The reaction mixture is allowed to warm to RT and stirs for 2 days. The solvent is removed *in vacuo* and the residue is partitioned

25

between saturated aqueous  $K_2CO_3$  solution and chloroform-methanol (95:5). The aqueous layer is extracted with chloroform-methanol (95:5) twice. The combined organic layers are washed with brine, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with  $CHCl_3$ -MeOH- $NH_4OH$  (90:9:1) gives 90 mg (71%) of Example 28 as a white solid:  $^1H$  NMR (400 MHz,  $CD_3OD$ )  $\delta$  8.13, 7.62, 7.44, 7.33, 6.56, 3.84-3.81, 3.37, 3.09-3.04, 2.86-2.75, 2.69, 2.60-2.53, 2.45, 1.81-1.72, 1.41-1.34.

10 **Example 29:** *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-6-carboxamide•fumarate:

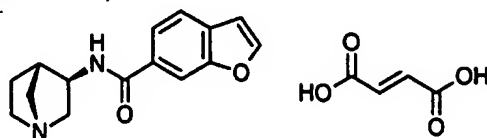


#### Method C

To a stirred solution of 1*H*-indole-6-carboxylic acid (81 mg, 0.5 mmol) in anhydrous DMF (10 mL) are added DIEA (265  $\mu$ L, 1.52 mmol) and *exo*-[2.2.1]-Amine (228 mg, 0.5 mmol). The mixture is cooled to 0°C, and HATU (190 mg, 0.5 mmol) is added in one portion. The reaction mixture is allowed to warm to RT and stirs overnight. The solvent is removed *in vacuo* and the residue is partitioned between saturated aqueous  $K_2CO_3$  solution and chloroform. The aqueous layer is extracted with chloroform (2x). The combined organic layers are washed with brine, dried ( $Na_2SO_4$ ), filtered and concentrated *in vacuo*. The crude product is purified by flash chromatography on silica gel. Elution with  $CHCl_3$ -MeOH- $NH_4OH$  (89:9:1) gives the free base as a yellow solid (84 mg, 66%).

To a stirred solution of the free base (84 mg, 0.33 mmol) in methanol (5 mL) is added a warm solution of fumaric acid (38 mg, 0.33 mmol) in methanol (5 mL). The mixture is stirred for 10 min at 50°C. The solvent is removed *in vacuo* and the remaining residue is diluted with acetone (5 mL). The mixture is stirred overnight at RT. The solid is collected by filtration, washed with acetone, and dried under high vacuum overnight to give 88 mg (72%) of Example 29 as a white solid:  $^1H$  NMR (400 MHz,  $CD_3OD$ )  $\delta$  11.38, 8.32-8.31, 7.94, 7.58-7.50, 6.54, 6.48, 3.86-3.82, 3.15-3.10, 2.97-2.89, 2.67-2.55, 1.78-1.69, 1.38-1.31.

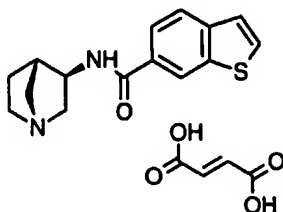
**Example 30:** *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide•fumarate:



5           1-Benzofuran-6-carboxylic acid is coupled with *exo*-[2.2.1]-Amine according to Method C making non-critical changes to give the free base as a yellow solid (237 mg, 91%) and Example 30 as a white solid (307 mg, 89%): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.07, 7.95-7.94, 7.81-7.72, 6.96-6.95, 6.71, 4.27-4.25, 3.75-3.69, 3.47-3.36, 3.27-3.22, 3.08-3.07, 2.23-2.14, 1.89-1.81.

10

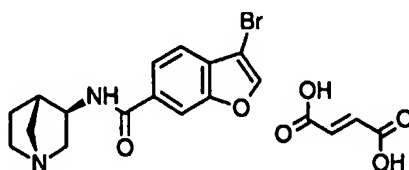
**Example 31:** *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-6-carboxamide•fumarate:



15           1-Benzothiophene-6-carboxylic acid is coupled with *exo*-[2.2.1]-Amine according to Method C, allowing the reaction to stir for 3 days and making non-critical changes to give the free base as a white solid (272 mg, 100%). The salt is obtained according to Method C, stirring the reaction at 40 °C for 10 min to afford Example 31 as a white solid (333 mg, 86%): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.47, 7.96, 7.86, 7.81, 7.48, 6.71, 4.27-4.24, 3.74-3.68, 3.46-3.35, 3.26-3.20, 3.07, 2.22-2.13, 1.87-1.81.

20

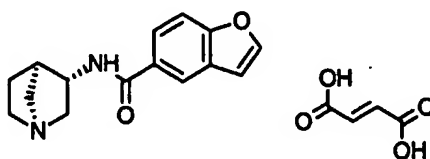
**Example 32:** *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-6-carboxamide•fumarate:



3-Bromo-1-benzofuran-6-carboxylic acid is coupled with *exo*-[2.2.1]-Amine according to Method C, allowing the reaction to stir for 2 days and making non-critical changes to give the free base as a light yellow oil (287 mg, 100%). The salt is obtained according to Method C, stirring the reaction at 40 °C for 10 min to afford

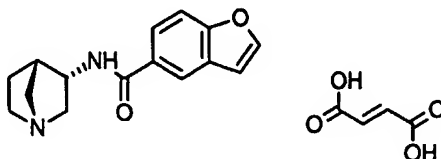
- 5 **Example 32** as a white solid (303 mg, 80%): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.15, 8.06, 7.96, 7.67, 6.71, 4.28-4.26, 3.75-3.70, 3.49-3.37, 3.28-3.23, 3.08, 2.23-2.15, 1.89-1.82.

**Example 33:** *N*-[(*exo*-4*R*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide•fumarate:



- 1-Benzofuran-5-carboxylic acid is coupled with *exo*-(4*R*)-[2.2.1]-Amine according to Method C, allowing the reaction to stir for 2 days and making non-critical changes to give the free base as a yellow solid (510 mg, 100%). The salt is obtained according to Method C, stirring the reaction at 40 °C for 30 min to afford
- 15 **Example 33** as a white solid (670 mg, 90%): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.19, 7.89-7.75, 7.61, 6.97, 6.71, 4.26-4.23, 3.73-3.68, 3.45-3.35, 3.26-3.20, 3.07, 2.21-2.13, 1.88-1.80.

- 20 **Example 34:** *N*-[(*endo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide•fumarate and *N*-[(*endo*-4*R*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide•fumarate:

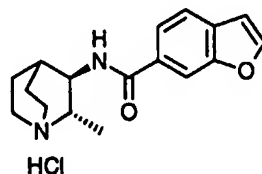


- 1-Benzofuran-5-carboxylic acid is coupled with racemic *endo*-[2.2.1]-Amine according to Method C, stirring for 2 days, making non-critical changes to afford the free base as a racemic mixture (440 mg, 98%). The racemic product is resolved by chiral chromatography using a Chiralcel OJ column to afford 190 mg (43%) of the (-)-enantiomer and 160 mg (36%) of the (+)-enantiomer. The fumarate salts of both
- 25



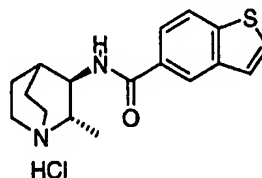
enantiomers are made according to Method C, making non-critical changes.  $^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.21, 7.89-7.85, 7.62, 6.98, 6.71, 4.70-4.65, 3.88-3.82, 3.51-3.35, 3.29-3.27, 3.16-3.11, 2.23-2.16, 2.14-2.05.

- 5 **Example 35:** *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide hydrochloride:



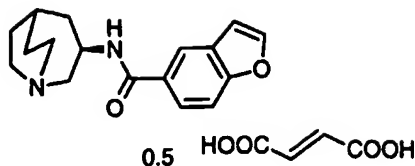
- 1-Benzofuran-6-carboxylic acid (0.16g, 1.0mmol), HATU (0.46g, 1.2mmol) and 2*S*-methyl-2.2.2-Amine (0.213g, 1.0mmol) are dissolved in 12mL  $\text{CH}_3\text{CN}$ . DIEA (1.4mL, 8.0mmol) is added dropwise. After 3 days, the solvent is removed *in vacuo*. The residue is taken up in  $\text{CHCl}_3$ , 1N NaOH is added and the mixture is extracted with  $\text{CHCl}_3$ . The combined organic layers are dried ( $\text{MgSO}_4$ ), filtered and concentrated. The residue is purified by chromatography (Biotage 40S, 90:9:1  $\text{CHCl}_3/\text{MeOH}/\text{NH}_4\text{OH}$ ). The hydrochloride salt is prepared and recrystallized from MeOH/EtOAc to provide 203mg (63%) of the product. HRMS (FAB) calculated for  $\text{C}_{17}\text{H}_{20}\text{N}_2\text{O}_2+\text{H} = 285.1603$ , found 285.1617.

**Example 36:** *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide hydrochloride:



- 1-Benzothiophene-5-carboxylic acid is coupled with 2*S*-methyl-2.2.2-Amine and the hydrochloride salt is prepared following the procedure of Example 35, making non-critical changes to afford Example 36 (137mg, 73%). HRMS (FAB) calculated for  $\text{C}_{17}\text{H}_{20}\text{N}_2\text{OS}+\text{H}$  301.1375, found 301.1380.

- 25 **Example 37:** *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide•0.5fumarate:



1-benzofuran-5-carboxylic acid is coupled with 3(R)-[3.2.2]-Amine according to Method C making non-critical changes to give the free base as a white solid (220 mg, 77%) and Example 37 as a white solid (90 mg, 66%): <sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD) δ 8.16, 7.88, 7.82, 7.60, 6.97, 6.69, 4.75-4.65, 3.70, 3.50-3.41, 3.41-3.20, 3.04, 2.48-2.33, 2.14-1.93, 1.87.

### **Materials and Methods for Determining α7 nAChR Agonist Activity**

#### **Cell-based Assay for Measuring the EC<sub>50</sub> of α7 nAChR Agonists**

##### **Construction and expression of the α7-5HT<sub>3</sub> receptor:**

The cDNA encoding the N-terminal 201 amino acids from the human α7 nAChR that contain the ligand binding domain of the ion channel was fused to the cDNA encoding the pore forming region of the mouse 5HT<sub>3</sub> receptor as described by Eisele JL, et al., Chimaeric nicotinic-serotonergic receptor combines distinct ligand binding and channel specificities, Nature (1993), Dec. 2;366(6454):479-83, and modified by Groppi, et al., WO 00/73431. The chimeric α7-5HT<sub>3</sub> ion channel was inserted into pGS175 and pGS179 which contain the resistance genes for G-418 and hygromycin B, respectively. Both plasmids were simultaneously transfected into SH-EP1 cells and cell lines were selected that were resistant to both G-418 and hygromycin B. Cell lines expressing the chimeric ion channel were identified by their ability to bind fluorescent α-bungarotoxin on their cell surface. The cells with the highest amount of fluorescent α-bungarotoxin binding were isolated using a Fluorescent Activated Cell Sorter (FACS). Cell lines that stably expressed the chimeric α7-5HT<sub>3</sub> were identified by measuring fluorescent α-bungarotoxin binding after growing the cells in minimal essential medium containing nonessential amino acids supplemented with 10% fetal bovine serum, L-glutamine, 100 units/ml penicillin/streptomycin, 250 ng/mg fungizone, 400 μg/ml hygromycin B, and 400

μg/ml G-418 at 37° C with 6% CO<sub>2</sub> in a standard mammalian cell incubator for at least 4 weeks in continuous culture.

#### **Assay of the activity of the chimeric α7-5HT<sub>3</sub> receptor**

5        To assay the activity of the α7-5HT<sub>3</sub> ion channel, cells expressing the channel were plated into each well of either a 96 or 384 well dish (Corning #3614) and grown to confluence prior to assay. On the day of the assay, the cells were loaded with a 1:1 mixture of 2 mM Calcium Green 1, AM (Molecular Probes) dissolved in anhydrous DMSO and 20% pluronic F-127 (Molecular Probes). This solution was added directly  
10    to the growth media of each well to achieve a final concentration 2 μM. The cells were incubated with the dye for 60 min at 37° C and then washed with a modified version of Earle's balanced salt solution (MMEBSS) as described in WO 00/73431. The ion conditions of the MMEBSS was adjusted to maximize the flux of calcium ion through the chimeric α7-5HT<sub>3</sub> ion channel as described in WO 00/73431. The  
15    activity of compounds on the chimeric α7-5HT<sub>3</sub> ion channel was analyzed on FLIPR. The instrument was set up with an excitation wavelength of 488 nanometers using 500 milliwatts of power. Fluorescent emission was measured above 525 nanometers with an appropriate F-stop to maintain a maximal signal to noise ratio. Agonist activity of each compound was measured by directly adding the compound to cells expressing  
20    the chimeric α7-5HT<sub>3</sub> ion channel and measuring the resulting increase in intracellular calcium that is caused by the agonist-induced activation of the chimeric ion channel. The assay is quantitative such that concentration-dependent increase in intracellular calcium is measured as concentration-dependent change in Calcium Green fluorescence. The effective concentration needed for a compound to cause a 50%  
25    maximal increase in intracellular calcium is termed the EC<sub>50</sub>. The examples were tested and have EC<sub>50</sub> values from about 25 nM to about 10,000 nM:

#### **Binding Constants:**

30        Another way for measuring α7 nAChR agonist activity is to determine binding constants of a potential agonist in a competition binding assay. For α7 nAChR agonists, there is good correlation between functional EC<sub>50</sub> values using the chimeric α7-5HT<sub>3</sub> ion channel as a drug target and binding affinity of compounds to the endogenous α7 nAChR.

### Membrane Preparation.

Male Sprague-Dawley rats (300-350g) are sacrificed by decapitation and the brains (whole brain minus cerebellum) are dissected quickly, weighed and  
5 homogenized in 9 volumes/g wet weight of ice-cold 0.32 M sucrose using a rotating pestle on setting 50 (10 up and down strokes). The homogenate is centrifuged at 1,000 x g for 10 minutes at 4 °C. The supernatant is collected and centrifuged at 20,000 x g for 20 minutes at 4 °C. The resulting pellet is resuspended to a protein concentration of 1 - 8 mg/mL. Aliquots of 5 mL homogenate are frozen at -80 °C  
10 until needed for the assay. On the day of the assay, aliquots are thawed at rt and diluted with Krebs' - 20 mM Hepes buffer pH 7.0 (at rt) containing 4.16 mM NaHCO<sub>3</sub>, 0.44 mM KH<sub>2</sub>PO<sub>4</sub>, 127 mM NaCl, 5.36 mM KCl, 1.26 mM CaCl<sub>2</sub>, and 0.98 mM MgCl<sub>2</sub>, so that 25 - 150 µg protein are added per test tube. Proteins are determined by the Bradford method (Bradford, M.M., *Anal. Biochem.*, 72, 248-254,  
15 1976) using bovine serum albumin as the standard.

### Binding Assay.

For saturation studies, 0.4 mL homogenate are added to test tubes containing buffer and various concentrations of radioligand, and are incubated in a final volume  
20 of 0.5 mL for 1 hour at 25 °C. Nonspecific binding was determined in tissues incubated in parallel in the presence of 0.05 mls MLA for a final concentration of 1 µM, added before the radioligand. In competition studies, drugs are added in increasing concentrations to the test tubes before addition of 0.05 mls [<sup>3</sup>H]-MLA for a final concentration 3.0 to 4.0 nM. The incubations are terminated by rapid vacuum  
25 filtration through Whatman GF/B glass filter paper mounted on a 48 well Brandel cell harvester. Filters are pre-soaked in 50 mM Tris HCl pH 7.0 - 0.05 % polyethylenimine. The filters are rapidly washed two times with 5 mL aliquots of cold 0.9% saline and then counted for radioactivity by liquid scintillation spectrometry.

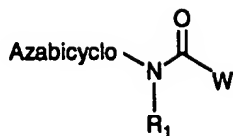
### Data Analysis.

30 In competition binding studies, the inhibition constant (K<sub>i</sub>) was calculated from the concentration dependent inhibition of [<sup>3</sup>H]-MLA binding obtained from non-linear regression fitting program according to the Cheng-Prusoff equation (Cheng, Y.C. and Prusoff, W.H., *Biochem. Pharmacol.*, 22, p. 3099-3108, 1973). Hill

coefficients were obtained using non-linear regression (GraphPad Prism sigmoidal dose-response with variable slope).

What is claimed:

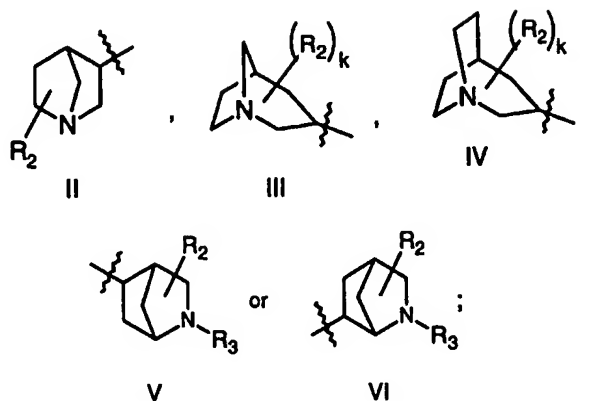
1. A compound of the Formula I:



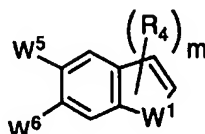
5

Formula I

wherein Azabicyclo is



W is



10                      R<sub>1</sub> is H, alkyl, halogenated alkyl, cycloalkyl, substituted phenyl, or substituted naphthyl;

                         R<sub>2</sub> is H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

                         k is 1 or 2, provided that when k is 2, each R<sub>2</sub> is other than H;

15                      R<sub>3</sub> is H, lower alkyl, lower substituted alkyl, or lower halogenated alkyl;

                         W<sup>1</sup> is O, S, or N(R<sub>15</sub>);

                         W<sup>5</sup> and W<sup>6</sup> are independently H or a bond to the carbonyl of Formula I, provided that only one of W<sup>5</sup> and W<sup>6</sup> is said bond and the other is H;

                         Each R<sub>4</sub> is independently H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, halogenated alkynyl, substituted alkynyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl,

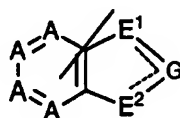
20

heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, lactam heterocycloalkyl, phenyl, substituted phenyl, -OR<sub>10</sub>, -SR<sub>10</sub>, -SOR<sub>10</sub>, -SO<sub>2</sub>R<sub>10</sub>, -NR<sub>10</sub>C(O)R<sub>5</sub>, -NR<sub>10</sub>C(O)R<sub>6</sub>, -NR<sub>10</sub>C(O)R<sub>8</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -NO<sub>2</sub>, -C(O)R<sub>10</sub>, -CN, -C(O)<sub>2</sub>R<sub>10</sub>, -C(O)NHR<sub>10</sub>, -SCN, -S(O)NHR<sub>10</sub>, -S(O)<sub>2</sub>NHR<sub>10</sub>, -NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, R<sub>5</sub>, or R<sub>6</sub>, provided that when R<sub>4</sub> is -SO<sub>1-2</sub>R<sub>10</sub> or -CO<sub>1-2</sub>R<sub>10</sub> and R<sub>10</sub> is heterocycle, halogenated heterocycle or heterocycle substituted with 1 substituent selected from R<sub>13</sub>, a carbon in the heterocycle is bonded to the carbon or sulfur;

m is 1 or 2, provided that when m is 2 each R<sub>4</sub> is other than H;

R<sub>5</sub> is a 5-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms independently selected from the group consisting of -O-, =N-, -N(R<sub>16</sub>)-, and -S-, and having 0-1 substituent selected from R<sub>9</sub>, and further having 0-3 substituents independently selected from F, Cl, Br, or I,

or R<sub>5</sub> is a 9-membered fused-ring moiety having a 6-membered ring fused to a 5-membered ring and having the formula



wherein each A is independently CR<sub>14</sub> or N, provided that only up to one A is N, E<sup>1</sup> and E<sup>2</sup> are independently selected from CR<sub>14</sub>, O, S, or NR<sub>16</sub>, and G is CR<sub>14</sub>, provided that R<sub>14</sub> or R<sub>16</sub> can be a bond when --- forms a double bond and further provided that only one R<sub>14</sub> or R<sub>16</sub> can be a bond for bonding R<sub>5</sub> to a moiety to which it is attached;

R<sub>6</sub> is a 6-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms selected from =N- and having 0-1 substituent selected from R<sub>9</sub> and 0-3 substituent(s) independently selected from F, Cl, Br, or I,

or R<sub>6</sub> is a 10-membered heteroaromatic bi-cyclic moiety containing within one or both rings 1-3 heteroatoms selected from =N-, each 10-membered fused-ring moiety having 0-1 substituent selected from R<sub>9</sub>, and 0-3 substituent(s) independently selected from F, Cl, Br, or I;

Each R<sub>8</sub> is independently H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, phenyl, or phenyl substituted with 0-4 independently selected from F, Cl, Br, I, or R<sub>9</sub>;

R<sub>9</sub> is alkyl, substituted alkyl, halogenated alkyl, -OR<sub>11</sub>, -CN, -NO<sub>2</sub>, -NR<sub>10</sub>R<sub>10</sub>;

Each R<sub>10</sub> is independently H, alkyl, cycloalkyl, heterocycloalkyl, alkyl substituted with 1 substituent selected from R<sub>13</sub>, cycloalkyl substituted with 1 substituent selected from R<sub>13</sub>, heterocycloalkyl substituted with 1 substituent selected from R<sub>13</sub>, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, phenyl, or substituted phenyl;

Each R<sub>11</sub> is independently H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, or halogenated heterocycloalkyl;

R<sub>13</sub> is -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -SOR<sub>11</sub>, -SO<sub>2</sub>R<sub>11</sub>, -C(O)NR<sub>11</sub>R<sub>11</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>;

Each R<sub>14</sub> is independently bond, H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, F, Cl, Br, I, or a bond, provided that the fused-ring moiety has 0-1 substituent selected from alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, or -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, and further provided that the fused-ring moiety has 0-3 substituent(s) selected from F, Cl, Br, or I;

R<sub>15</sub> is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

Each R<sub>16</sub> is independently bond, H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

or pharmaceutical composition, pharmaceutically acceptable salt, racemic mixture, and pure enantiomer thereof.

2. The compound of claim 1, wherein m is 1.
3. The compound of claim 2, wherein R<sub>1</sub> is H, lower alkyl, or cycloalkyl.
4. The compound of claim 3, wherein R<sub>2</sub> is H, lower alkyl, lower halogenated alkyl, or lower substituted alkyl.
5. The compound of claim 4, wherein R<sub>2</sub> is H, or methyl.



6. The compound of claim 5, wherein W is 5-benzofuranyl, 6-benzofuranyl, 5-benzothieryl, or 6-benzothieryl, any of which is optionally substituted with lower alkyl, lower halogenated alkyl, lower alkynyl, halogen, cyano, aminocarbonyl, formyl, or acetyl.
7. The compound of claim 6, wherein Azabicyclo is II.
8. The compound of claim 7, wherein the compound is
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-5-carboxamide;
- N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,6-dicarboxamide;
- N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,5-dicarboxamide;
- 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;
- 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-6-carboxamide;
- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-5-carboxamide;
- N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,6-dicarboxamide;
- N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,5-dicarboxamide;

- N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-5-carboxamide; or a  
5 pharmaceutically acceptable salt thereof.
9. The compound of claim 6, wherein Azabicyclo is III and k is 1.
10. The compound of claim 9, wherein the compound is  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
10 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
15 *N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
20 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
25 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
30 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;

*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-6-carboxamide;  
5 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1*H*-indole-5-carboxamide; or a  
pharmaceutically acceptable salt thereof.

- 10 11. The compound of claim 6, wherein Azabicyclo is IV and k is 1.  
12. The compound of claim 11, wherein the compound is  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
15 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,5-dicarboxamide;  
20 2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
25 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
30 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;

- N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
5 *N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1*H*-indole-6-carboxamide;  
10 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1*H*-indole-5-carboxamide; or a  
pharmaceutically acceptable salt thereof.

13. The compound of claim 6, wherein Azabicyclo is V or VI and R<sub>3</sub> is H.

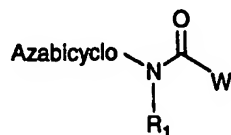
14. The compound of claim 13, wherein the compound is

- 15 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-6-carboxamide;  
20 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
25 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
30 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-6-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
5 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,5-dicarboxamide;  
10 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-6-carboxamide;  
15 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,5-dicarboxamide;  
20 2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-6-carboxamide;  
25 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-5-carboxamide;  
30 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-5-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-5-carboxamide;  
5 *N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,5-dicarboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-5-carboxamide; or  
pharmaceutically acceptable salt thereof.
- 10 15. A pharmaceutical composition comprising a compound according to any one of claims 1-14, anti-psychotic agent(s), and a pharmaceutically acceptable excipient.
16. The pharmaceutical composition according to claim 15, wherein said compound and said agent are to be independently administered rectally, topically, orally, sublingually, or parenterally for a therapeutically effective interval.
- 15 17. The pharmaceutical composition according to claim 15, wherein said compound is administered in an amount of from about 0.001 to about 100 mg/kg of body weight of said mammal per day.
18. The pharmaceutical composition according to claim 15, wherein said compound is administered in an amount of from about 0.1 to about 50 mg/kg of body  
20 weight of said mammal per day.
19. The pharmaceutical composition according to claim 15, comprising a compound according to any one of claims 1-14 and a pharmaceutically acceptable excipient.
20. The pharmaceutical composition according to claim 19, wherein said  
25 compound is administered rectally, topically, orally, sublingually, or parenterally for a therapeutically effective interval.
21. The pharmaceutical composition according to claim 19, wherein said compound is administered in an amount of from about 0.001 to about 100 mg/kg of body weight of said mammal per day.
- 30 22. The pharmaceutical composition according to claim 19, wherein said compound is administered in an amount of from about 0.1 to about 50 mg/kg of body weight of said mammal per day.

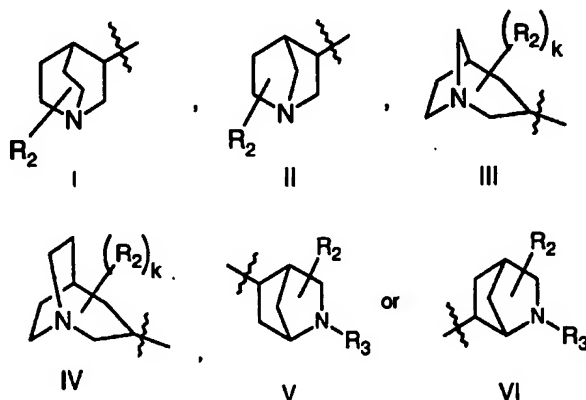
23. A method for treating a disease or condition in a mammal in need thereof, wherein the mammal would receive symptomatic relief from the administration of an  $\alpha 7$  nicotinic acetylcholine receptor agonist comprising administering to the mammal a therapeutically effective amount of a compound according to Formula I:



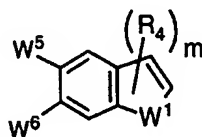
5

Formula I

wherein Azabicyclo is



W is



10

$R_1$  is H, alkyl, halogenated alkyl, cycloalkyl, substituted phenyl, or substituted naphthyl;

$R_2$  is H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

15  $R_3$  is H, lower alkyl, lower substituted alkyl, or lower halogenated alkyl;

$k$  is 1 or 2, provided that when  $k$  is 2, each  $R_2$  is other than H;

$W^1$  is O, S, or N( $R_{15}$ );

$W^5$  and  $W^6$  are independently H or a bond to the carbonyl of Formula I, provided that only one of  $W^5$  and  $W^6$  is said bond and the other is H;

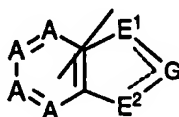
20 Each  $R_4$  is independently H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, halogenated alkynyl,

substituted alkynyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, lactam heterocycloalkyl, phenyl, substituted phenyl, -OR<sub>10</sub>, -SR<sub>10</sub>, -SOR<sub>10</sub>, -SO<sub>2</sub>R<sub>10</sub>, -NR<sub>10</sub>C(O)R<sub>5</sub>, -NR<sub>10</sub>C(O)R<sub>6</sub>, -NR<sub>10</sub>C(O)R<sub>8</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -NO<sub>2</sub>, -C(O)R<sub>10</sub>, -CN, -C(O)<sub>2</sub>R<sub>10</sub>, -C(O)NHR<sub>10</sub>, -SCN, -S(O)NHR<sub>10</sub>, -S(O)<sub>2</sub>NHR<sub>10</sub>, -NR<sub>10</sub>S(O)<sub>2</sub>R<sub>10</sub>, R<sub>5</sub>, or R<sub>6</sub>, provided that when R<sub>4</sub> is -SO<sub>1-2</sub>R<sub>10</sub> or -CO<sub>1-2</sub>R<sub>10</sub> and R<sub>10</sub> is heterocycle, halogenated heterocycle or heterocycle substituted with 1 substituent selected from R<sub>13</sub>, a carbon in the heterocycle is bonded to the carbon or sulfur;

m is 1 or 2, provided that when m is 2 each R<sub>4</sub> is other than H;

R<sub>5</sub> is a 5-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms independently selected from the group consisting of -O-, =N-, -N(R<sub>16</sub>)-, and -S-, and having 0-1 substituent selected from R<sub>9</sub>, and further having 0-3 substituents independently selected from F, Cl, Br, or I,

or R<sub>5</sub> is a 9-membered fused-ring moiety having a 6-membered ring fused to a 5-membered ring and having the formula



wherein each A is independently CR<sub>14</sub> or N, provided that only up to one A is N, E<sup>1</sup> and E<sup>2</sup> are independently selected from CR<sub>14</sub>, O, S, or NR<sub>16</sub>, and G is CR<sub>14</sub>, provided that R<sub>14</sub> or R<sub>16</sub> can be a bond when --- forms a double bond and further provided that only one R<sub>14</sub> or R<sub>16</sub> can be a bond for bonding R<sub>5</sub> to a moiety to which it is attached;

R<sub>6</sub> is a 6-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms selected from =N- and having 0-1 substituent selected from R<sub>9</sub> and 0-3 substituent(s) independently selected from F, Cl, Br, or I,

or R<sub>6</sub> is a 10-membered heteroaromatic bi-cyclic moiety containing within one or both rings 1-3 heteroatoms selected from =N-, each 10-membered fused-ring moiety having 0-1 substituent selected from R<sub>9</sub>, and 0-3 substituent(s) independently selected from F, Cl, Br, or I;

Each R<sub>8</sub> is independently H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, phenyl, or phenyl substituted with 0-4 independently selected from F, Cl, Br, I, or R<sub>9</sub>;



$R_9$  is alkyl, substituted alkyl, halogenated alky,  $-OR_{11}$ ,  $-CN$ ,  $-NO_2$ ,  $-NR_{10}R_{10}$ ;

Each  $R_{10}$  is independently H, alkyl, cycloalkyl, heterocycloalkyl, alkyl substituted with 1 substituent selected from  $R_{13}$ , cycloalkyl substituted with 1 substituent selected from  $R_{13}$ , heterocycloalkyl substituted with 1 substituent selected from  $R_{13}$ , halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, phenyl, or substituted phenyl;

Each  $R_{11}$  is independently H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, or halogenated heterocycloalkyl;

$R_{13}$  is  $-OR_{11}$ ,  $-SR_{11}$ ,  $-N(R_{11})_2$ ,  $-C(O)R_{11}$ ,  $-SOR_{11}$ ,  $-SO_2R_{11}$ ,  $-C(O)NR_{11}R_{11}$ ,  $-CN$ ,  $-CF_3$ ,  $-NR_{11}C(O)R_{11}$ ,  $-S(O)_2N(R_{11})_2$ ,  $-NR_{11}S(O)_2R_{11}$ , or  $-NO_2$ ;

Each  $R_{14}$  is independently bond, H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl,  $-OR_{11}$ ,  $-SR_{11}$ ,  $-N(R_{11})_2$ ,  $-C(O)R_{11}$ ,  $-NO_2$ ,  $-C(O)N(R_{11})_2$ ,  $-CN$ ,  $-NR_{11}C(O)R_{11}$ ,  $-S(O)_2N(R_{11})_2$ ,  $-NR_{11}S(O)_2R_{11}$ , F, Cl, Br, I, or a bond, provided that the fused-ring moiety has 0-1 substituent selected from alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl,  $-OR_{11}$ ,  $-SR_{11}$ ,  $-N(R_{11})_2$ ,  $-C(O)R_{11}$ ,  $-NO_2$ ,  $-C(O)N(R_{11})_2$ ,  $-CN$ ,  $-NR_{11}C(O)R_{11}$ ,  $-S(O)_2N(R_{11})_2$ , or  $-NR_{11}S(O)_2R_{11}$ , and further provided that the fused-ring moiety has 0-3 substituent(s) selected from F, Cl, Br, or I;

$R_{15}$  is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

Each  $R_{16}$  is independently bond, H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl; or pharmaceutical composition, pharmaceutically acceptable salt, racemic mixture, or pure enantiomer thereof.

24. The method of claim 23, wherein  $R_1$  is H, lower alkyl, or cycloalkyl.

25. The method of claim 24, wherein  $R_2$  is H, lower alkyl, lower halogenated alkyl, or lower substituted alkyl.

26. The method of claim 25, wherein  $R_2$  is H, or methyl.

27. The method of claim 26, wherein m is 1 and W is 5-benzofuranyl, 6-benzofuranyl, 5-benzothieryl, or 6-benzothieryl, any of which is optionally substituted with lower alkyl, lower halogenated alkyl, lower alkynyl, halogen, cyano, aminocarbonyl, formyl, or acetyl.

5

28. The method of claim 27, wherein Azabicyclo is I.

29. The method of claim 28, wherein the compound is

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;

10 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;

*N*-6-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;

15 *N*-5-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;

2-acetyl-*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;

2-acetyl-*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;

20 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;

25 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;

30 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;

*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;

- N*-6-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide; or a  
5 pharmaceutically acceptable salt thereof.

30. The method of claim 28, wherein the compound is  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;  
10 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-(1-azabicyclo[2.2.2]oct-3-yl)]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
15 *N*-5-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
20 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
25 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
30 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
35 *N*-5-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;

*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide;  
 or a pharmaceutically acceptable salt thereof.

- 5 31. The method of claim 27, wherein Azabicyclo is II.
32. The method of claim 31, wherein the compound is  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
 10 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,5-dicarboxamide;  
 15 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;  
 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
 20 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
 25 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
 30 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,5-dicarboxamide;

*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(*exo-4S*)-1-azabicyclo[2.2.1]hept-3-yl]-1*H*-indole-5-carboxamide; or a  
5 pharmaceutically acceptable salt thereof.

33. The method of claim 27, wherein Azabicyclo is III and k is 1.

34. The method of claim 33, wherein the compound is

*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
10 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
15 *N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
20 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
25 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
30 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;

- N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-6-carboxamide;  
 5 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1*H*-indole-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1*H*-indole-5-carboxamide; or a  
 pharmaceutically acceptable salt thereof.

- 10 35. The method of claim 27, wherein Azabicyclo is IV and k is 1.  
 36. The method of claim 35, wherein the compound is  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
 15 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,5-dicarboxamide;  
 20 2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
 2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
 25 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
 30 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;

- N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
 5 *N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1*H*-indole-6-carboxamide;  
 10 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1*H*-indole-5-carboxamide; or a  
 pharmaceutically acceptable salt thereof.

37. The method of claim 27, wherein Azabicyclo is V or VI and R<sub>3</sub> is H.

38. The method of claim 37, wherein the compound is

- 15 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-6-carboxamide;  
 20 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,5-dicarboxamide;  
 2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
 2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
 25 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
 30 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-6-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
5 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,5-dicarboxamide;  
10 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-6-carboxamide;  
15 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,5-dicarboxamide;  
20 2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-6-carboxamide;  
25 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-5-carboxamide;  
30 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-5-carboxamide;



*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-5-carboxamide;  
5 *N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,5-dicarboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-5-carboxamide; or  
pharmaceutically acceptable salt thereof.

10

40. The method according to any one of claims 23-39, wherein the disease or condition is cognitive and attention deficit symptoms of Alzheimer's, neurodegeneration associated with diseases such as Alzheimer's disease, pre-senile dementia (mild cognitive impairment), or senile dementia.

15

41. The method according to any one of claims 23-39, wherein the disease or condition is schizophrenia or psychosis.

42. The method according to claim 41, wherein the mammal would receive  
20 symptomatic relief from the administration of a therapeutically effective amount of  $\alpha 7$  nicotinic acetylcholine receptor agonist and anti-psychotic agent(s) for a therapeutically effective interval.

43. The method according to any one of claims 23-39, wherein the disease or  
25 condition is depression, anxiety, general anxiety disorder, or post traumatic stress disorder.

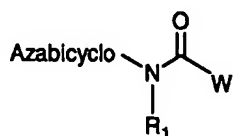
44. The method according to any one of claims 23-39, wherein the disease or condition is attention deficit disorder, or attention deficit hyperactivity disorder.

30

45. The method according to any one of claims 23-39, wherein the disease or condition is mood and affective disorders, amyotrophic lateral sclerosis, borderline personality disorder, traumatic brain injury, behavioral and cognitive problems in

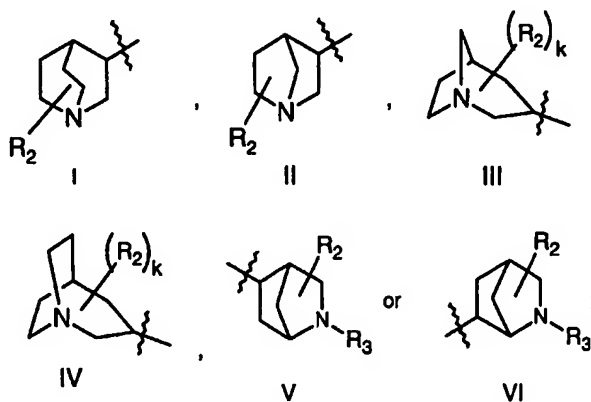
general and associated with brain tumors, AIDS dementia complex, dementia associated with Down's syndrome, dementia associated with Lewy Bodies, Huntington's disease, Parkinson's disease, tardive dyskinesia, Pick's disease, dysregulation of food intake including bulimia and anorexia nervosa, withdrawal  
 5 symptoms associated with smoking cessation and dependant drug cessation, Gilles de la Tourette's Syndrome, age-related macular degeneration, glaucoma, neurodegeneration associated with glaucoma, or symptoms associated with pain.

46. Use for the preparation of a medicament for treating a disease or condition,  
 10 wherein the mammal would receive symptomatic relief from the administration of a therapeutically effective amount of  $\alpha 7$  nicotinic acetylcholine receptor agonist using a compound according to Formula I:

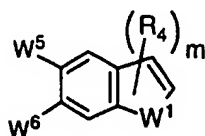


Formula I

15 wherein Azabicyclo is



W is



$\text{R}_1$  is H, alkyl, halogenated alkyl, cycloalkyl, substituted phenyl, or substituted  
 20 naphthyl;

$R_2$  is H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, or aryl;

$R_3$  is H, lower alkyl, lower substituted alkyl, or lower halogenated alkyl;

$k$  is 1 or 2, provided that when  $k$  is 2, each  $R_2$  is other than H;

5  $W^1$  is O, S, or N( $R_{15}$ );

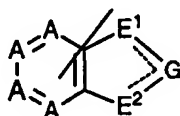
$W^5$  and  $W^6$  are independently H or a bond to the carbonyl of Formula I, provided that only one of  $W^5$  and  $W^6$  is said bond and the other is H;

Each  $R_4$  is independently H, F, Cl, Br, I, alkyl, halogenated alkyl, substituted alkyl, alkenyl, halogenated alkenyl, substituted alkenyl, alkynyl, halogenated alkynyl, 10 substituted alkynyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, lactam heterocycloalkyl, phenyl, substituted phenyl,  $-OR_{10}$ ,  $-SR_{10}$ ,  $-SOR_{10}$ ,  $-SO_2R_{10}$ ,  $-NR_{10}C(O)R_5$ ,  $-NR_{10}C(O)R_6$ ,  $-NR_{10}C(O)R_8$ ,  $-N(R_{10})_2$ ,  $-NO_2$ ,  $-C(O)R_{10}$ ,  $-CN$ ,  $-C(O)_2R_{10}$ ,  $-C(O)NHR_{10}$ ,  $-SCN$ ,  $-S(O)NHR_{10}$ ,  $-S(O)_2NHR_{10}$ ,  $-NR_{10}S(O)_2R_{10}$ ,  $R_5$ , or 15  $R_6$ , provided that when  $R_4$  is  $-SO_{1-2}R_{10}$  or  $-CO_{1-2}R_{10}$  and  $R_{10}$  is heterocycle, halogenated heterocycle or heterocycle substituted with 1 substituent selected from  $R_{13}$ , a carbon in the heterocycle is bonded to the carbon or sulfur;

$m$  is 1 or 2, provided that when  $m$  is 2 each  $R_4$  is other than H;

$R_5$  is a 5-membered heteroaromatic mono-cyclic moiety containing within the 20 ring 1-3 heteroatoms independently selected from the group consisting of  $-O-$ ,  $=N-$ ,  $-N(R_{16})-$ , and  $-S-$ , and having 0-1 substituent selected from  $R_9$ , and further having 0-3 substituents independently selected from F, Cl, Br, or I,

or  $R_5$  is a 9-membered fused-ring moiety having a 6-membered ring fused to a 5-membered ring and having the formula



25

wherein each A is independently  $CR_{14}$  or N, provided that only up to one A is N,  $E^1$  and  $E^2$  are independently selected from  $CR_{14}$ , O, S, or  $NR_{16}$ , and G is  $CR_{14}$ , provided that  $R_{14}$  or  $R_{16}$  can be a bond when  $---$  forms a double bond and further provided that only one  $R_{14}$  or  $R_{16}$  can be a bond for bonding  $R_5$  to a moiety to which it is attached;

$R_6$  is a 6-membered heteroaromatic mono-cyclic moiety containing within the ring 1-3 heteroatoms selected from =N- and having 0-1 substituent selected from  $R_9$  and 0-3 substituent(s) independently selected from F, Cl, Br, or I,

or  $R_6$  is a 10-membered heteroaromatic bi-cyclic moiety containing within one or both rings 1-3 heteroatoms selected from =N-, each 10-membered fused-ring moiety having 0-1 substituent selected from  $R_9$ , and 0-3 substituent(s) independently selected from F, Cl, Br, or I;

Each  $R_8$  is independently H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, substituted heterocycloalkyl, phenyl, or phenyl substituted with 0-4 independently selected from F, Cl, Br, I, or  $R_9$ ;

$R_9$  is alkyl, substituted alkyl, halogenated alkyl, -OR<sub>11</sub>, -CN, -NO<sub>2</sub>, -NR<sub>10</sub>R<sub>10</sub>;

Each  $R_{10}$  is independently H, alkyl, cycloalkyl, heterocycloalkyl, alkyl substituted with 1 substituent selected from  $R_{13}$ , cycloalkyl substituted with 1 substituent selected from  $R_{13}$ , heterocycloalkyl substituted with 1 substituent selected from  $R_{13}$ , halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, phenyl, or substituted phenyl;

Each  $R_{11}$  is independently H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, or halogenated heterocycloalkyl;

$R_{13}$  is -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -SOR<sub>11</sub>, -SO<sub>2</sub>R<sub>11</sub>, -C(O)NR<sub>11</sub>R<sub>11</sub>, -CN, -CF<sub>3</sub>, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, or -NO<sub>2</sub>;

Each  $R_{14}$  is independently bond, H, alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, F, Cl, Br, I, or a bond, provided that the fused-ring moiety has 0-1 substituent selected from alkyl, cycloalkyl, heterocycloalkyl, halogenated alkyl, halogenated cycloalkyl, halogenated heterocycloalkyl, substituted alkyl, substituted cycloalkyl, substituted heterocycloalkyl, -OR<sub>11</sub>, -SR<sub>11</sub>, -N(R<sub>11</sub>)<sub>2</sub>, -C(O)R<sub>11</sub>, -NO<sub>2</sub>, -C(O)N(R<sub>11</sub>)<sub>2</sub>, -CN, -NR<sub>11</sub>C(O)R<sub>11</sub>, -S(O)<sub>2</sub>N(R<sub>11</sub>)<sub>2</sub>, or -NR<sub>11</sub>S(O)<sub>2</sub>R<sub>11</sub>, and further provided that the fused-ring moiety has 0-3 substituent(s) selected from F, Cl, Br, or I;

R<sub>15</sub> is H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl;

Each R<sub>16</sub> is independently bond, H, alkyl, halogenated alkyl, substituted alkyl, cycloalkyl, halogenated cycloalkyl, substituted cycloalkyl, heterocycloalkyl, halogenated heterocycloalkyl, or substituted heterocycloalkyl; or pharmaceutical composition, pharmaceutically acceptable salt, racemic mixture, or pure enantiomer thereof.

47. The use of claim 46, wherein R<sub>1</sub> is H, lower alkyl, or cycloalkyl.
48. The use of claim 47, wherein R<sub>2</sub> is H, lower alkyl, lower halogenated alkyl, or lower substituted alkyl.
49. The use of claim 48, wherein R<sub>2</sub> is H, or methyl.
50. The use of claim 49, wherein m is 1 and W is 5-benzofuranyl, 6-benzofuranyl, 5-benzothieryl, or 6-benzothieryl, any of which is optionally substituted with lower alkyl, lower halogenated alkyl, lower alkynyl, halogen, cyano, aminocarbonyl, formyl, or acetyl.

51. The use of claim 50, wherein Azabicyclo is I.
52. The use of claim 51, wherein the compound is
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;
- N*-6-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;
- N*-5-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;
- 2-acetyl-*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;
- 2-acetyl-*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;
- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;

- N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
5 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
10 *N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
15 *N*-5-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide; or  
pharmaceutically acceptable salt thereof.
- 20 53. The use of claim 51, wherein the compound is  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-6-  
carboxamide;  
25 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-(1-azabicyclo[2.2.2]oct-3-yl)]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
30 2-acetyl-*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;

- N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
5 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
10 *N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
15 *N*-5-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(2*S*,3*R*)-2-methyl-1-azabicyclo[2.2.2]oct-3-yl]-1-benzothiophene-5-carboxamide;  
or a pharmaceutically acceptable salt thereof.

20 54. The use of claim 50, wherein Azabicyclo is II.

55. The use of claim 54, wherein the compound is

- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
25 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-2,5-dicarboxamide;  
30 2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
35 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-methyl-1-benzofuran-5-carboxamide;

- N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
5 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
10 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzofuran-3,5-dicarboxamide;  
15 *N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(*exo*-4*S*)-1-azabicyclo[2.2.1]hept-3-yl]-1-benzothiophene-5-carboxamide; or a  
pharmaceutically acceptable salt thereof.

56. The use of claim 50, wherein Azabicyclo is III and k is 1.

- 20 57. The use of claim 56, wherein the compound is  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
25 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-6-carboxamide;  
30 2-acetyl-*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-methyl-1-benzofuran-5-carboxamide;



- N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
5 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
10 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,6-dicarboxamide;  
*N*-5-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzofuran-3,5-dicarboxamide;  
15 *N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*,5*R*)-1-azabicyclo[3.2.1]oct-3-yl]-1-benzothiophene-5-carboxamide; or a  
pharmaceutically acceptable salt thereof.

58. The use of claim 50, wherein Azabicyclo is IV and k is 1.
- 20 59. The use of claim 58, wherein the compound is  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-methyl-1-benzofuran-5-carboxamide;  
25 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,6-dicarboxamide;  
*N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-6-carboxamide;  
30 2-acetyl-*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-2-formyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-6-carboxamide;

- N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-methyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-6-carboxamide;  
 5 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-chloro-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-bromo-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-ethynyl-1-benzofuran-5-carboxamide;  
 10 *N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,6-dicarboxamide;  
 15 *N*-5-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzofuran-3,5-dicarboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-6-carboxamide;  
*N*-[(3*R*)-1-azabicyclo[3.2.2]non-3-yl]-1-benzothiophene-5-carboxamide; or a  
 pharmaceutically acceptable salt thereof.

20 60. The use of claim 50, wherein Azabicyclo is V or VI and R<sub>3</sub> is H.

61. The use of claim 60, wherein the compound is

- N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-6-carboxamide;  
 25 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-2,5-dicarboxamide;  
 30 2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-6-carboxamide;  
 2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-2-formyl-1-benzofuran-5-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
5 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-chloro-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
10 *N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-3-cyano-1-benzofuran-5-carboxamide;  
15 *N*-6-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzofuran-3,5-dicarboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-5-yl)-1-benzothiophene-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
20 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-cyano-1-benzofuran-5-carboxamide;  
25 *N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-2,5-dicarboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-6-carboxamide;  
2-acetyl-*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-6-carboxamide;  
30 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-2-formyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-methyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-6-carboxamide;

- N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-isopropyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-chloro-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-6-carboxamide;  
 5 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-bromo-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-ethynyl-1-benzofuran-5-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-prop-1-ynyl-1-benzofuran-5-carboxamide;  
 10 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-6-carboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-3-cyano-1-benzofuran-5-carboxamide;  
*N*-6-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,6-dicarboxamide;  
*N*-5-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzofuran-3,5-dicarboxamide;  
*N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-6-carboxamide;  
 15 *N*-(2-azabicyclo[2.2.1]hept-6-yl)-1-benzothiophene-5-carboxamide; or  
 pharmaceutically acceptable salt thereof.

62. The use according to any one of claims 46-61, wherein the disease or condition is cognitive and attention deficit symptoms of Alzheimer's, neurodegeneration  
 20 associated with diseases such as Alzheimer's disease, pre-senile dementia (mild cognitive impairment), or senile dementia.

63. The use according to any one of claims 46-61, wherein the disease or condition is schizophrenia or psychosis.  
 25

64. The use of claim 63, wherein the mammal would receive symptomatic relief from the administration of a therapeutically effective amount of  $\alpha 7$  nicotinic acetylcholine receptor agonist and anti-psychotic agent(s) for a therapeutically effective interval.  
 30

65. The use according to any one of claims 46-61, wherein the disease or condition is depression, anxiety, general anxiety disorder, or post traumatic stress disorder.

66. The use according to any one of claims 46-61, wherein the disease or condition is attention deficit disorder, or attention deficit hyperactivity disorder.

67. The use according to any one of claims 46-61, wherein the disease or condition  
5 is mood and affective disorders, amyotrophic lateral sclerosis, borderline personality disorder, traumatic brain injury, behavioral and cognitive problems in general and associated with brain tumors, AIDS dementia complex, dementia associated with Down's syndrome, dementia associated with Lewy Bodies, Huntington's disease, Parkinson's disease, tardive dyskinesia, Pick's disease, dysregulation of food intake  
10 including bulimia and anorexia nervosa, withdrawal symptoms associated with smoking cessation and dependant drug cessation, Gilles de la Tourette's Syndrome, age-related macular degeneration, glaucoma, neurodegeneration associated with glaucoma, or symptoms associated with pain.